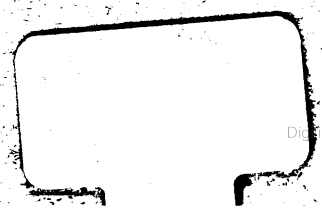

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Prof. Carmichael
with the Author's regards

SCIENCE AND THE BIBLE;

A REVIEW OF

"THE SIX DAYS OF CREATION" OF PROF. TAYLER LEWIS.

BY

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ARTICLE III.

SCIENCE AND THE BIBLE.

A REVIEW OF "THE SIX DAYS OF CREATION" OF PROF. TAYLER LEWIS.[1]

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"THE heavens declare the glory of God, and the firmament showeth his handiwork." Thus spake the Psalmist in view of the revelation which God had made of himself in his works. With deeper emphasis may we now utter the same ascription of praise; for that revelation, as its records have been unfolded in these later days, has opened more and more glorious thoughts of the Almighty Architect, and appears as unfathomable in its truths, as God himself is infinite. The world in general is satisfied to see this glory as exhibited in form, color, magnitude, and other outside quali-

[1] The Six Days of Creation, or the Scriptural Cosmology, with the Ancient Idea of Time-Worlds in distinction from Worlds in Space. By Tayler Lewis, Professor of Greek in Union College. 12mo. pp. 407. Schenectady, 1855.

ties. The external attributes of existences have indeed been graciously made so transcendent in beauty and full of harmonies, that "he may run that readeth." But there are also revelations below the surface, open to those who will earnestly look for them. For God's hand was never outstretched to create, but beauty and wisdom appeared in every tracing; and, if seemingly wanting in the outer vestments, they are still profoundly exhibited through the structure beneath, in the ordering of the parts from which the externals are educed, and in the universal laws there contained; these are literally secrets of the Almighty, to be diligently "sought out of all them that have pleasure therein."

Who are they that are trying to open this book of revelation? 'Men of Science' they are sometimes called; 'Students of Nature' is their true position. Nearly all the world besides pass the revelation by unheeded, almost as if God were only the God of external nature, a maker of pretty forms, colors, and fragrances on a grand scale. Many even speak contemptuously of him, who, in the study of stones, insects, or worms, busies himself with endeavors to read those records of God's wisdom. In the style and spirit of the Atheist, they decry his pursuits, and strive to throw opprobrium on all of the sect. They may think better of some, who deal with worlds, and mountains, and large quadrupeds, perhaps; as if material size were a measure of truth with God. They seem not to know that the minutest living being is as much above a universe of dead worlds as life is superior to matter.

This unworthy spirit is mainly due to prejudice and ignorance. They say that science, after all its claims, is no nearer to explaining the ultimate nature of matter or of life, than centuries ago, and at the same time decry its "boasted" laws. And here is a fatal misconception of science. Has metaphysical or sacred Science yet explained the nature of God or spirit? or has any mind yet measured eternity? The ultimate nature of matter or of life is as much beyond all investigation. Science claims not to fathom it; is not so presumptuous as to hope for success, although examples are

at hand of this prying into mysteries among many writers on the second revelation. These subjects are neither within its bounds or aims. It seeks only to ascertain the laws which God has established in nature, or rather, the methods in which he is constantly working in the universe, his plan or system, ordained in infinite wisdom and sustained in infinite power. Man were presumptuous in his searchings, were he not made in the image of God. Thus endowed, if also teachable in spirit, he may read and understand, and reach onward in his knowledge to brighter and brighter revelations.

Newton, by a flash of his intellect, conceived of the law of gravitation; and as he, inquiringly, looked around and above, he everywhere found testimony that the conception was a fact, a comprehensive truth. At once, cycles and epicycles, and all the cobwebs of past ages vanished, and our planetary system and the vast universe stood forth in its majestic extent, the whole like a vision from on high. After the thousands of years that the world had existed, there was, at last, a correct apprehension of the actual relations in space of the heavenly bodies. He announced the law of attraction and its ratio, called it, for convenience, the law of gravitation; and by it, the great highways in the heavens have been traced. What before had been thought out, and thereupon received as true, proved to be wrong in fact and principle. But who will say that we do not now *know* the relations of the heavenly bodies, and the law of their motions? This law is as immutable as God's will, for it is his ordinance. Newton did not dream about the cause or nature of gravitation; he had read the law, and rejoiced in the revealed truth.

Crystallization opens to us other laws, no less comprehensive. All are familiar with the pretty geometrical forms of some crystals. But the observing eye sees the world full of crystals. When it snows, the heavens are showering down crystals, for every flake is a congeries of crystalline grains, and they are often in elegant symmetrical forms. When the waters freeze, they become a mass of crystals, only so

blended that we distinguish not their outlines. When sea-water evaporates, it drops crystals freely; for every grain of salt that goes down, is itself a gem. A bar of iron is broken, and its whole texture proves to be an aggregation of crystal particles, showing the angular lines and cleavage of true crystallization. The granite of the hills is but a mountain of crystals; and every pudding-stone, although made of pebbles, has myriads of crystalline grains or fragments of crystals in and among those pebbles. Finally, the special fact first noted, develops into a general truth or law, that cohesion in the inorganic kingdom producing solidification, is actually crystallization; that we not merely see nature geometrizing, but matter in its profoundest quality governed by geometrical principles; and therefore that cohesion in solidification is not a sort of agglutination acting in all directions alike, which would be well enough for making spheres, but an axial or polar attraction, bringing out symmetrical forms according to fixed laws.

Examining further, more definite laws come out: each species or kind of substance, wherever found or however made, proves to have its distinct and constant fundamental crystalline form, so unvarying in angles and structure, although admitting of modifications by simple ratios, that it may be as easily known by it, as an animal by its form. These crystalline forms are cubes, square prisms, rhombic prisms either right or oblique, etc.; and in each case, the axes of the prisms, that is, their relative dimensions, admit of mathematical calculation.

Thus by widening our field of vision from the single fact to universal nature, we learn that molecules have their specific forms or dimensions, and cohesion in solids its mathematical basis. This fundamental quality of cohesion is sustained by every other characteristic of crystals: the hardness is different in the direction of *unequal* axes; so also the transparency, elasticity, conduction of heat, and refraction of light; and all in exact accordance with the law of symmetry in the crystal. Do we not see, here, that the very molecules, of which the universe is built, were modelled variously and

with precision by the hand of Deity? Looking deeper still, we learn that these molecules are not, like the blocks of an architect, squared and cornered for one place alone, but have their laws according to which they are adapted to numberless forms and structures. Gaining entrance to these inner temples of nature, we recognize, everywhere, the appointments of Him whose glories are infinite.

The chemist reads Nature in another of her departments: he watches the changes going on around him, and the changes which Nature, in her work, passes through in his laboratory. He thence learns not merely the absurdity of the ancient fancy that water, air, earth, and fire are elements, and not only that these are true elements, and that water is made of two, oxygen and hydrogen, and so each substance has its elemental constitution; but he goes further: he discovers, as his facts accumulate, that there is a law in these combinations; that oxygen and hydrogen, for example, unite only in certain ratios; that they exist in water in the ratio of 8 to 1 by weight; that, in another compound containing oxygen and iron, the ratio is 8 to 28; in another, containing oxygen and nitrogen, the ratio is 8 (oxygen) to 14 (nitrogen), or else, 8 to 28, 8 to 42, 8 to 56, 8 to 70, equivalent, in parts, to 1 : 1, 1 : 2, 1 : 3, 1 : 4, 1 : 5 parts; and so, throughout Nature, in compounds of all kinds, he ascertains that the elements have their definite combining ratios, and combining weights; and thence he learns to calculate, with the utmost precision, the constitutions of compounds.

Here then is a fundamental law of attraction, at the basis of chemistry, and upon it the science rests. It is a law of numbers and harmonic relations — the ordained will of God, which the chemical student has been enabled to apprehend, and is now endeavoring to follow out into all of its beautiful developments. No future research can revoke that will. The supposed elements may be resolved into others; but all matter, organic and inorganic, is constituted upon this law; and the law must stand, until the Being who said, "So let it be," reverses all Nature and his own enactment.

In the study of Light, the division of the beam into its

component colored rays, was a first fact; the different refrangibilities of those rays, a second. Then came the law that each color corresponds to a specific rate of vibration or of wave motion: the vibrations were measured; and finally, whatever the freaks of light, they were found to be explainable by the interferences and other inter-actions of just such rays with these specific rates of vibration. This established, science says: "sic Deus vult," and pays Him the homage due.

Thus we might go on with the departments of physical science, heat, magnetism, electricity, and others; and in all, it would appear, that science has reached immutable laws, simply by comparing one tracing in nature with another, and thus reading the hand-writing of God in his works. The attraction of gravitation, chemical attraction, cohesive attraction, light, heat, electricity, may yet be referred to some higher laws: they may be found to be but the workings of a common law, embracing the whole; and to this, science is tending. But in so doing, what are now laws will stand firm as laws under a more general law; what is knowledge will be knowledge still.

The laws in the kingdoms of life are of similar import, equally intelligible to the humble pupil of nature, and, if possible, more grand in their scope and relations.

The great universal law for all life Moses announced when speaking of the institution of the first life-kingdom, in the words: "which has seed in itself;" for this is the fundamental characteristic of living beings, as distinct from inorganic existence.

The evolution of the germ — in its essence, a simple memberless cellule — resulting in a successive individualization of parts: the more fundamental first; then, by degrees, leading on to the completed complex organism in all its details, is an exhibition of another grand law of the highest significance; one, in an important sense, typical of all progress.

The spiral line of development as the initial in evolution, and retained in its perfection in the spiral arrangement of leaves in plants, as well as in the parts of some animals, is

another grand law, which science has evolved from the mass of facts before us in the plant-kingdom. And this law has its more special announcements: follow the leaves, from one leaf (A) as a starting point around the stem, taking the course of the spiral, to another leaf (B) in the same vertical line with the first; and if there are 2 or 3 leaves in the spiral, the spiral goes around but once before reaching leaf B; if there are 5 leaves in the spiral, the spiral revolves 2 times before it reaches leaf B; if there are 8 leaves, it revolves 3 times; if 13 leaves, it revolves 5 times; if 21 leaves, 8 times; and so on, and the converse, by an inflexible rule. Placing the number of leaves above, and number of turns below, the following series expresses the relation: — $\frac{2}{1}$ $\frac{3}{1}$ $\frac{5}{2}$ $\frac{8}{3}$ $\frac{13}{5}$ $\frac{21}{8}$ etc. Now the last 8, the number of revolutions for a spiral of 21 leaves, is the sum of 5 and 3 of the two next preceding spirals in the series; and 21, of 13 and 8 of the same two preceding spirals. In this way the series extends on, in exact mathematical relation. Thus law rises above law, in God's plan, to mathematical harmonies; and when we shall establish the connection between the nature of growth and the production of such spirals, this will be still another law, not obliterating the former, but only opening a profounder view into the mysteries of creation.

In the animal kingdom also, there are laws above laws in a long progression. There are relations of structure or concurrent conditions that run through the kingdom as a whole; others for each class; others still of less profound character, but no less strict or beautiful, for each order, or family, or genus; and then in a species itself there are still other analogies between different parts, which are like higher tones in the grand system of harmonies. These science has partly studied out, and still she labors to comprehend them all.

As one example: after tracing the analogies of parts between the fore and hind limbs of a quadruped, it has gone on and shown that in the Divine plan, one system or type of structure is at the basis of the arm of man, the leg of the horse or lion, the wing of the bird, the paddle of the whale

and pectoral fin of the fish; and so precisely, that the homologous bones may be traced, and the changes or obsolescence of this or that bone, as the type becomes adapted to its various purposes. There is in this unity of structure an expression of one single fundamental idea.

This kind of research has been further pursued, and it has been found that there is a like parallelism through the whole structure even to the relations of every bone in fishes, reptiles, birds, quadrupeds, and man; so that there is one type at the basis of all.

Still deeper has investigation gone; and now we know that in a single vertebra and its appendages, all the elements of the bony structure in these classes of animals are comprised, the repetition and modifications of a type-vertebra, with its accessories, producing all the various results.

Thus God throughout nature has evolved diversity out of unity, eliciting ten thousand concordances out of single profound enactments in His plan of creation.

These laws are universal truths, limited so far only as the range of objects to which they relate is limited. Thus any truth with regard to *life* which characterizes all living beings, is a law in the Science of Life. So as to the leaves of plants, any quality which is found to be a universal truth, as for instance their spiral arrangement, as explained, or their function of respiration, or their general structure, is a law in the Science of Plants. The chemical combination of elements in simple ratio and according to constant equivalents by weight, is another law or universal truth; and the general truths relating to the dependence of chemical combinations on heat, light, or electricity, are other laws. The parallel relations of structure or homologies between all vertebrates, is another law, universal as regards the vertebrates; and the other great groups have their corresponding laws. The reciprocal relations between the parts of an animal, due to the fact of type-structures, as between the hoof, leg, teeth, stomach, etc., through the structure, which is so exact, that a knowledge of one of these parts is equivalent to a knowledge of the general nature of all, is another law or universal truth.

Thus there are laws having reference to forces, motion, form, dimensions, general structure, functions, affinities of family, class, etc.; homological type-relations; reciprocal relations between the parts of a structure; development or growth, whether organic or inorganic. And such facts or conditions may be considered also with reference to one another, and afford still other laws; or specially with regard to forces or influences of any kind; and in this line are mainly what we call causalities. They may all be of various grades of generality; and they may be reduced in some instances to mathematical expressions, in which last case we reach nearest to the prototype enactments of Divinity.

Such laws are literally announcements of concordances in nature. They are not in any sense phenomena, but expressions of the relations of phenomena. They proceed from the oneness of system in the universe. They may rise above one another, in a grand series, and all still be true as laws; for they are exhibitions of the lines of truth which run through nature, all emanating from the will of the Supreme Architect.

In electricity, magnetism, and some related departments, the term *fluid* is commonly used, but only as a help in the expression of general truths. The science is not in the fluid, nor is the idea of a fluid a part of the science. The science consists of enunciations of general relations observed, and general methods of action or change; that is, the comprehensive facts or truths which research has developed.

The illustrations which have been given are sufficient to make clear the true goal of science, that toward which it has been moving with unceasing progress since man turned from excursions of fancy, and became an earnest and faithful learner at the footstool of his Maker. Nature, to such a one, is not a mere collection of things, of trees, and rocks, and animals, and man, but of living activities harmonious in plan and action.

These explanations may, to some, seem trite or out of place; and they would be actually so, were there not lamentable ignorance where we have a right to look for knowledge.

The work cited at the head of this Article, is an example to the point. Knowing something of the position and standing of the author, we had opened the book to receive therefrom such light as learning could give on the word of God in Genesis. We found much truth, well expressed and argued, with some philosophical notions as to causalities and phenomena, and much arrogance and error. We had heard that the author sustained the conclusions arrived at by geologists regarding the days of Genesis; and found the conclusions, indeed, but accompanied with sneers at geology and all science, which betokened a mind unfit for research. We found, too, a loose use of the Sacred Record, and a limited comprehension of the grandeur of its truths, which no less surprised us.

On the subject of facts and laws in nature, the author gives us early an exhibition of the depth of his philosophy. In a note on pages 38, 39, he explains his views with some detail. He writes out the mathematical expression :

$$P \quad p_1 \quad p_2 \quad p_3 \quad p \quad p_5 \cdots\cdots p_n \cdots\cdots X.$$

as a series representing a higher and higher stage of causation from the fact or directly observed phenomenon P, to X the initial or most remote "act, fact, or energy;" and observes that, on attaining a knowledge of p_2, a higher energy or causality than p_1, p_1 then becomes *phenomenal* or a *manifestation*, and so on; so that P, p_1, p_2, p_3, etc., all below p_n are phenomenal to p_n, if that be a known "fact, act, or energy." After thus explaining himself, and adding other illustrations, he says : —

"Making an application of such views to science generally, we might say, the n th terms at the present stage of discovery are to be found in such words as *gravitation*, *magnetism*, *crystallization*, *elasticity*, etc. These do yet stand for *energies* or *causalities*, because there has not yet been discovered that still more remote energy of which they are *manifestations*, and which when discovered will convert them all into *phenomena*, that is, *make them appear*."

Hence, in opposition to all that has been said, knowledge is *not* knowledge. Since science is necessarily finite, and therefore its results cannot reach nearer to X than p_n, *ergo*, not only its present laws, but all the future may develop,

are ephemeral, fated, to the last one, or all but the last, to become "phenomena" in the progress of learning; one charnel-house for the whole, "cycles," "epicycles," "magnetisms," "gravities," "elephants," "turtles," etc. A hopeless prospect ahead for those who reason from or about nature; and we wonder when Professor Lewis was propounding his laws with regard to nature, in the following pages of his work, he did not fear lest they might, hereafter, be doomed to a place by the side of the "elephants."

That we may not appear to misrepresent him, we cite further:

Page 220: "Science may boast as she pleases, but according to her own most vaunted law, she can only trace the footsteps of a present or once-passing causation;" as if the laws of matter and of all existence were as mutable as the changing seasons.

In the same spirit, he speaks of the progress of science (p. 180), rendering "childish and obsolete all the doctrines and all the language in which she now so proudly boasts."

After a very cutting rebuke for the "savans of the nineteenth century" (p. 107), he observes that "the language of science, when it fails or has become obsolete, exhibits always the appearance of childish folly and pretence;" and then, after a few sentences, goes off as follows:

"Science has indeed enlarged our field of thought, and for this we will be thankful to God, and to scientific men. But what is it after all, that she has given us, or can give us, but a knowledge of phenomena, appearances? What are her boasted laws but generalizations of such phenomena ever resolving themselves into some one great fact that *seems* to be an original energy, whilst evermore the application of a stronger lens to our analytical telescope resolves such seeming primal force into an *appearance*, a manifestation of something still more remote, which, in this way, and in this way alone, reveals its presence to our senses. Thus the course of human science has ever been the substitution of one set of conceptions for another. Firmaments have given place to concentric spheres, spheres to empyreans, empyreans to cycles and epicycles, epicycles to vortices, vortices to gravities and fluids ever demanding for the theoretic imagination other fluids as the only conditions on which their action could be made conceivable."

The error of our profound author is plain enough after the remarks which have been made. The connection, in the same category, of ancient dreams with discovered laws,

laws deduced by science after experiencing the vanity of man's imaginings and turning to God's works as a sure fountain of knowledge, is certainly remarkable as a specimen of learning; and it abounds on other pages. We hardly know to what to refer the blindness that cannot see the wide gulf between "vortices" and "gravities."

On p. 170, again, he remarks on the "ever-increasing darkness of science," "unaided by any higher beams," not aware that science is itself an emanation from the Source of light. On page 110, he says well of the Book of God, though in the same perverse tone about science: "This grand Old Book of God still stands, and will continue to stand, though science and philosophy are ever changing their countenances and passing away."

Once more, we quote a forcible illustration, which presents his views in few words: "We may smile," he says, "at the old quackish story of the earth's standing on the back of the elephant, and the elephant standing on the head of a tortoise, etc.; but in our gravities, our magnetisms, our series of fluids, ever requiring other fluids to explain their motions, we have only introduced a new set of modern equivalents."

There is much more of the same sort. At first, this slashing away at science excited amusement, reminding us of the contest between Sancho and the windmill: but then, pain, that an infidel philosophy should have emanated from such a source. This placing in antagonism God's word and his works, or the results of the study of his works, is only fitted to make the young scout the former; for they know the latter has its great truths, having the best of all evidence.

Had the author simply condemned the false that is mixed with science, or the atheism that substitutes force or nature for God, it would have been well. But notwithstanding an occasional admission of good accomplished, he reprobates science in its foundation and essence, and also all who dare to believe, — very much, indeed, in the spirit of the Cardinals who judged Galileo.

But science is still alive; her progress is sure; and in her

readings of God's works, His word is daily finding support, fuller elucidation, and increasing sublimity.

In this attack upon science, which is a sort of by-play quite unessential to the object of the work, geology of course gets double share. And, strange to say, the author is at the same time sustaining essentially the conclusions of geologists. He adopts and proves, on exegetical grounds, that the days of Genesis were long periods of time, and speaks quite freely of the æons and æons, saying that the "feeling of the vast, the indefinite, the unmeasured, once received into the soul [in the opening period], is carried naturally through all the other periods" (p. 96); and, at first, we gathered that he and geologists were agreed. But when all seemed to be flowing on smoothly, suddenly the geologist gets an unmannerly rap for taking too much time. It would seem to be a trivial fault in a case where all is acknowledged to be so "indefinite," and where the periods are periods in the work of a Being who has existed from eternity; and especially since, if we go back even "billions of years" for each day, we get no nearer to the beginning of that eternity. But still it is not pardoned. The author thinks it gives too much time to the age of "Fungi and sea-weeds;" indeed, he says: "it is very strange that fungi, at least some fungi, should exist at all" (p. 172). He is not aware that geology accords somewhat with his notion; for it finds no Fungi whatever until the later periods of the globe. He does not anywhere mention the exact length of time which, consistently with divine wisdom, the periods could have occupied. But, although objecting so decidedly to a long age of Fungi, he thinks that a state of "huge nebulosity," "with an absence of solidity and cohesion," might have been continued "for millions and millions of years" (p. 60). Again (p. 398), he remarks, with some temper (alluding to geologists and the Bible), as follows: "Neither does the Bible mean what you, in your little science and still less Biblical learning, would ascribe to it. Your stale caricatures belong neither to its prose nor its poetry: they are alike alien to its letter and its spirit."

The author exhibits a constant fear lest geology should

teach something, and that thereby a belief, based on truth from such a source (he has it — "on Buckland, Lyell, or Hugh Miller"), should be substituted for a belief grounded on the Scriptures, which would be, he says, "a wretched self-deception;" — lamentable, indeed, if we should admit of help from God's works in understanding His writings!

In another place, he says of geology (p. 98): "Infidel as her spirit often is," she is "driven, more and more, to acknowledge the mixture of the natural and supernatural in the production of the earth:" very much, we think, as a current is driven by the boat it carries; for geology first proved that "the natural" was involved in creation, and, with a rare exception, has always admitted the supernatural; and she has finally drawn off exegesis so completely into the same course that some, like Prof. Lewis, as they are hurried on by the current, exclaim in great glee over their wonderful progress, and, in remarkable self-complacency, look down frowning upon the current that they imagine is trying to keep up with them.

As to infidel geology — the science which, almost alone, put down the pantheistic "Vestiges of Creation" and its "development theory," was geology. Not a geologist, in his writings, has supported the work; and the facts proving successive creations, in past time, instead of evolutions of species from species, have been uniformly regarded as conclusive against that theory. Yet our author admits that "a development theory, in the sense of species from species, may be as pious as any other," and may, possibly, have been true. He needs the bit of science to curb his fancy.

The work is remarkable for the confident air with which it brings forward principles that cautious science is slow to utter, thus dictating to nature in the true style of the old philosophy, while, at the same time, not adopting, or "caring" to recognize, any results established by geology or the other sciences. But it is useless to enter into further details.

We come now to the special subject of the work, "the six days of creation, or a Scriptural cosmology." We will first give briefly the general course of doctrine in the volume.

The six days are six periods, "indefinite, vast;" still, he says, not so long as "very flippantly and very ignorantly" asserted by geologists.

Creation, in the very beginning of beginnings, was a creation out of nothing. But Moses probably did not mean a real *bona fide* beginning either in the first or second verse of Genesis. The words of our author are (p. 45): "whatever may be believed, in respect to this first origination of matter, whether of the earth or of all worlds, there is good reason for doubting whether it is actually meant to be set forth either in the beginning or in any other part of this account." He says of the primal or originating force, in, or constituting, nature, that it is not "the divine power continually energizing in space;" but that "it is a real entity distinct from God, which God has originated, and to which he has given an immanent existence of its own in space and time." This is "the great ultimate fact of facts in the physical world." (p. 47).

The formless and void earth was probably a "huge nebulosity," as just now cited. But "how it came in such a condition, no one can say; whether it was the result of a progress or a deterioration, we have no means of knowing, either from reason or revelation." The creation of Genesis, was no creation, even *ab initio*, but rather a fashioning in or upon matter previously existing, "a separating, a dividing, a clearing up, a bringing into order, an arranging of outward relations." The original matter may have had only "the dead force of cohesion;" but at "the beginning" to which Moses refers, there was added "an inward power, a separating, arranging, selecting, organic power," and this was "the beginning of life, although, as yet, exhibited only in the chemical aspect, rather than the higher modes in which it afterwards energized" (p. 65).

The first effect of the new life was the elimination of light" (p. 65). And as light succeeded to darkness, a finished work to time when the work was not begun, so by a natural figure, morning succeeded to evening, or light to night, "boker" to "ereb." Thus the first day passed.

Creation thus begun, was throughout, a *growth*, a *generation*, as *Genesis*, in Greek signifies. Accordingly (p. 114), "there are the days or periods of quickening, and then, supervening on them, a season or seasons of repose, in which physical law, the physical law both of the material and the sentient nature, carries on the processes thus begun, or thus renewed. As the fœtus grows in this *hidden world*, which the Psalmist compares to the lowest parts of the earth, there is doubtless a most important part performed by nature." The author, seeing himself on the verge of an abyss then adds: "yet if we would avoid the grossest materialism, we must conclude that there are some things, even in this seemingly *natural* process, which nature never could have done, — something to which all her chemistry and all her laws of physical life, could never have given the beginning of existence."

The *second* day was the "evolving from the yet semi-chaotic world, that we now call the atmosphere" (p. 104); "the origination and completion of that apparatus of physical law, or that physical state of things, be it scientifically whatever it may — for we do not yet know in all respects what it is — by which were produced the combined appearances of the clouds, the blue heavens, together with other *outward* revealing phenomena connected with, and representative of, such interior causality." The author in this connection afterwards apologizes for his indefiniteness by a fling at unfortunate science, observing (p. 105), that "the more scientific our statements, the more abstract and conceptionless are they, etc."

On the *third* day, dry land appears coming up out of the waters through natural causes. The consideration of the creation of vegetation is passed over to the *fifth* day.

On the *fourth* day, the sun, moon and stars, long before created, became visible to the earth, or "made their APPEARANCE in the firmament." The sun was perhaps now first brought into the same planetary system with the earth; or else a veil was removed; or it then first became luminous; or the matter of the sun did not before exist; or in some way, the sun became visible.

On these several points, Prof. Lewis says (p. 136): "Science is dumb, and revelation says nothing;" and again as to the establishment of the relation of the earth and the sun at that time, he remarks with equal confidence (p. 144): "science cannot say anything for or against such a view;" and again: "how can science say whether there was then any revolution of the earth upon its axis or not," and so on to a depth the reader can explore on page 145. Science seems to haunt the author like a horrible ghost, and his cudgel is always up. After all this and much more, he adds as follows, in which the remarks on vegetation are noteworthy:

"We may conclude that at this fourth period, partly contemporary with vegetation, and before the earliest dawn of animal life, the sun assumed towards our earth the state and form of a luminous body, and the adjustment of the shorter periodic seasons commenced . . . . All that we can say is, that at this period the solar system was lit up, the phosphorescent light which the earth may have possessed went out as the planet became more dense, the veil was taken from the central luminary, in order that now there might be not only light and warmth, which existed before, but such *regulated* diversities of them as would be required for the later vegetation as well as for the animal and human life" (pp. 147, 148).

Between the chapters on the fourth and fifth days, a discussion comes in again on the word *day*, and on time, and the uses of the sun, which it is unnecessary here to consider.

The *fifth* day is now taken up, when the author speaks of the creation of vegetation, and animals generally, exclusive of man. The expressions, "Let the waters bring forth," "Let the earth bring forth," are explained thus:

"In its general effect, [the general effect of the account by Moses,] and still more, in the conceptions which lie at the roots of its most important terms, it forces upon the mind the idea of *a nature in the earth* acting through a real dynamical process of its own, and in periods, which, whether longer or shorter, contain within themselves all the changes and successive stages which we find it impossible to dissociate from the thought of birth and growth. And this, too, of the animal as well as of the vegetable world" (pp. 211, 212).

Preparatory to this conclusion he had said (p. 200): "holding Nature thus to be, in some sense, a self-subsisting, self-

acting power," etc.; also, p. 199, "from the necessity of our laws of thinking, as well as from revelation, we say, that it [nature] is a power given originally by God. But, though thus originated, we can distinctly conceive of it as a nature, only when we regard it as in some manner left to itself and operating by its own laws or methods;" also, p. 204, "if we thus view Nature as a stream of causation governed by a certain law which not only regulates but limits its movements, then the *supernatural*, as its name imports, would be all *above nature*, in other words, that power of God which is employed 'according to the counsel of his own will' in originating, controlling, limiting, increasing, opposing, or terminating nature, whether it be the universal, or any particular or partial nature;" also, "it [the devout mind] loves to read how Nature, ever so obedient to her lord, is sometimes commanded to stand away from his presence."

After this, he observes that a development theory, of species from species, is pious enough, and Crosse's manufacture of *Acari* may be in harmony with law and gospel, provided the law have a divine origination; and in this provision the *naturalism* of the view escapes *atheism.*

The discussions which next follow, as to "what is meant by God's making the plant before it was in the earth," are not particularly edifying. The following chapter, on "the cyclical law of all natures," urges, that, from the analogy of day and night, summer and winter, life and death, sleep and activity, Nature has had its passivity and activity. The author "infers not only the *fact*, but the absolute *necessity* of repeated creative or supernatural acts; and this, not only to raise Nature, from time to time, to a higher degree, but to arouse and rescue her from that apparent death into which, when left to herself, she must ever fall" (p. 241). This is "the cyclical law of all natures." He quotes, approvingly (p. 243), the following thought from Plato's "strange myth," in the Politicus: "When God suffers Nature to take her course, all things tend to disorder, decay, and dissolution; when he resumes the helm, Nature moves on in her law of progress,

order comes again from disorder, growth from decay, and youth from age."

Finally, he comes to the *sixth* day, under which head, *having disposed of the quadrupeds in his remarks on the fifth day*, he speaks only of MAN. He thinks that possibly a perfect *primus homo* could have been made, by God, from the earth, like the animals (p. 247); but the record is against it, asserting that man was made in God's image, and therefore he admits that "the origin of man, as *man*, was special and peculiar;" by which he means, as he says, "his distinctive humanity, as separate from all that he has in common with the lower animals" (p. 248). He thinks, further, as follows:

"We are not much concerned about the mode of production of his material or merely physical organization. In regard to this, there is nothing in the expressions, 'He made,' or 'He created him,' or 'He made him from the earth,' which is at war with the idea of growth or development, during either a longer or shorter period. Ages might have been employed in bringing that material nature, through all the lower stages, up to the necessary degree of perfection for the higher use that was afterwards to be made of it. We do not say that the Bible teaches this; we do not think that any one would be warranted in putting any such interpretation upon it. There is, however, in itself, and aside from any question of interpretation, nothing monstrous or incredible in the idea that what had formerly been the residence of an irrational and grovelling tenant might now be selected as the abode of a higher life, might be fitted up in a manner corresponding to its new dignity, might be made to assume an erect heavenward position, whilst it takes on that beauty of face and form which would become the new intelligence, and indeed, be one of its necessary results."

In other words, a monkey may possibly have been curtailed behind and straightened up into a man.

The *seventh* day is regarded as now in progress and as including the period of spiritual existence beyond this life.

The prominent points, then, in the system are:

1. His personifying Nature, after Plato's notion; and, as a consequence, regarding her as, in a sense, "self-acting;" yet needing occasional supernatural acts, to rescue her from the decay or death to which she tends, and having alternately her time of rest and action.

2. Hence making mother earth to bring forth, through her

"parturitive powers" (p. 206), plants and animals, and even man, as far as his physical nature goes.

3. Admitting that matter is not eternal, but neglecting the obvious meaning of the phrase "In the beginning."

4. Admitting that the higher forms of vegetation were not created before the sun.

5. Regarding the creation of the sun and moon as "phenomenal."

6. Taking the days of Genesis to be indefinite periods.

7. Admitting the expression "evening and morning" to be metaphorical, and implying progress from the beginning to the full completion of a work, which, on the first day, was literally from darkness to light.

With regard to the last four points, geology can make little exception to Prof. Lewis's conclusions.

On the first three, the author and the "Vestiges of Creation" are pretty well agreed, except that Professor Lewis is less consistent in his use of Nature; and besides, he admits the occasional need of the supernatural to wake Nature from her slumbers, arrest decay, and give new momentum to her activity.

But is this Scriptural cosmology? We fail to find it in Genesis or elsewhere in the Bible. Successive days of evening and morning are announced; but does this imply that God or Nature needed rest? We have been led, from God's word as well as works, to conceive of Nature not only as God's initial work, but his constant work, ever sustained, and never left to go alone; and therefore no more requiring rest than God himself; no more capable of self-acting obedience than as God's own acts are obedient to himself. The world, in this sense, is full of God, though still not God; for these are only physical manifestations, which he ever continues, through the system he has established; while above all is a Moral Governor, a personal will supreme, which, by this system, which we call Nature, is working out physical, moral, and spiritual ends.

The successive phases or conditions in Nature may have, on such a ground, the character throughout of an evolution,

or the working of a single purpose, in all its lines of details, — as much so as in the opening flower. Yet this is so because God is infinite in power and wisdom, needs not to revise his plan or institute new principles; but, at the inception, saw the end and all the steps leading thereto, as a series or succession throughout perfect in law and harmony. In such a plan we have no right to say that God stands by to see Nature go alone; but that, unceasingly, he sustains and directs the glorious work by his power. We have not to conclude, in order to avoid materialism, that there are "some things" which Nature could never have done; for, in this view, there is nothing which, of itself, or in any sense as a self-existent activity, it can do.

This view, which shines forth from every page of the Bible, is as correctly a growth or Genesis, as that of Prof. Lewis; and all his argument, based on the progress of creation by periods, or on the meaning of the word *Genesis*, or of *φύσις* in Greek, or *natura* in Latin, or the alleged irrationality of any other view, does not go one step towards sustaining his peculiar notion of a huge self-acting something, now and then aroused to progress by God.

Although Prof. Lewis may not regard the fact, we observe that science does not suggest such a view of Nature.

The whole essence of physical Nature is expressed in a molecule; for molecular laws are the laws of physical Nature. The mere aggregation of molecules into stones or earth, however large the amount, does not give powers that are not contained in the minutest particles. Or, if many balls of such stones and earth are set afloat in space, they still do not make "Nature" with higher qualities than the molecular forces; and however great the effort of laboring Nature, we have no right to assume that those forces could make a living germ. The dirt of a laboratory had the misfortune to set afloat the idea of the creation of *Acari*, by Mr. Crosse. But science has yet no reason to deny that physical forces are physical forces.

In fact, life and physical or inorganic force are directly opposite in their tendencies. There are, in compounds, two

extremes: one, the inorganic and stable; the other, the organic and unstable; the former, the oxygen extreme; the latter, the carbon extreme. In inorganic Nature, as oxygen is the element of strongest affinity, the tendency is mostly to combination with oxygen or an analogous change, and this occasions the speedy dissolution of the organic structure when life disappears, and continued interchanges until the stable oxyds are produced. In life, on the contrary, there is a constant rising in the scale; that is, a movement in just the reverse direction, to compounds of carbon, hydrogen, and oxygen, or carbon, hydrogen, nitrogen, and oxygen, of greater and greater complexity; the stem of the plant thus preceding the formation of the higher material of the flower; or, in the animal, the albumen of the germ preceding the multiplied compounds of the structure and the highest of all compounds, as we believe it, the material of the brain. Inorganic and organic nature thus move in opposite directions.

Again, in inorganic Nature, increase of size is only accretion, and does nothing more than increase gravity. In the plant-kingdom of life, increase from the germ, besides increasing gravity, develops and sustains the organic structure, and produces a rising scale of chemical compositions. In the animal-kingdom, in addition to all the results just mentioned, there is a gradual development of mechanical force, from zero in the germ to its maximum in each species, besides also the force necessary to sustain the growth and functions of the individual, including mental action.

On scientific ground we should, therefore, conclude that physical force could not, by any metamorphosis or genesis, give rise to LIFE.

But again, suppose life to exist. This means simply living beings, as plants and animals, and implies conditions of chemical change, growth, and decay, in such beings. But we have no right to assert that any aggregation of such living beings, or amount of life, is capable of more than simply living and reproducing itself. The greatest possible result is accomplished when a living organism produces its like, in its young; for it is a result precisely equivalent, in power, to the

parent itself; that is, the power at work. Let there be a universe of worlds, full of living beings, and we still have no authority, from science, to assert the existence of a principle of life actuating that universe, beyond what belongs severally to each living being in it.

A study of Nature gives us, therefore, no basis for the notion of a living universal nature, capable more or less completely of self-development. Suppose the world to be in its condition of inorganic progress; we have no scientific ground for supposing that it could pass to a higher state, possessing living beings, by any parturient powers within. Or if life exists; we still get no hint as to the evolution of the four Sub-kingdoms of animal life from a universal germ; nor as to the origin of the Class-types, Order,—Family,—or Genus-types, or those of Species, each of which is a distinct idea in the plan of creation.

Nature in fact pronounces such a theory of evolution false, absolutely false, as we observe more particularly on a following page. It also proves the Divinity to be present at every step in creation, in the ordering of the globe in each physical feature, as well as in the plan and evolution of the life-kingdoms. The perpetual presence of Mind, infinite in power, wisdom, and love, and ever-acting, is so manifest in the whole history of the past, that the pantheistic theory which makes Nature God, is much the least absurd of the two. It regards Nature more in accordance with the analogies of a being like man, in which mind is uninterruptedly immanent, instead of an entity only now and then roused by an external mind. From the pantheistic doctrine we rise to true theism, by recognizing that whatever perfections belong to Nature, must be in or of God, as his power and attributes, and in an infinite degree. Hence physical attributes do not constitute God: for if we reject the idea that a sense of justice, truth, and love is evinced by the physical world, still man has these moral qualities; and therefore they must be among the attributes of Deity. And in addition, man has over all a free will; and therefore this also, but in its infinitude, must be an attribute of the God of Nature. Such a

Deity is not Nature itself, which is only a plan in development, but a personal being above Nature, while ever *in* nature by his power and wisdom.

Our conclusion therefore is, that Nature, self-existent and self-propagating, now and then requiring a jog from the supernatural, may be an interesting myth, but cannot rise to the same point of view with Biblical truth or sound philosophy.

But let us pass on. We need better argument than Prof. Lewis has brought forward, to convince us that the phrase, "In the beginning," does not mean what it says. We have regarded the announcement, in the first verse, of creation out of nothing by the will of God, a will free, supreme, omnific, as the grand point distinguishing the Mosaic cosmogony from the Egyptian and all others; almost like the very hand itself of God on the first line of the new revelation. But he would have us suppose that matter was made at some earlier beginning; and perhaps had had its ups and downs, and finally was worked over at a new beginning announced in the first verse. It is true the Hebrew word used in this place for *create*, does not signify, necessarily, creation out of nothing. Yet such an inference cannot be resisted without doing violence to the spirit of the text, and the fundamental laws of human belief. We would ask Prof. Lewis, what Hebrew word he could substitute for the one used, that would convey the precise idea of creation out of nothing? When he has found such a one, his reasoning may then demand consideration. "In the beginning" refers directly to the existing "heavens and earth" mentioned in the following part of the verse; that is, the existing universe. We may suspect the existence of a previous universe that came to nought before this began; but it cannot be made a question of reasonable belief, or a basis for argument.

Some other points in Professor Lewis's cosmology (he will excuse us if we substitute his own name for the term "scriptural") demand from us a passing remark.

With singular inconsistency, Professor Lewis admits a "huge nebulosity" for the "formless and void" state of the earth, makes the progress mainly one by natural causes, and

then speaks contemptuously (p. 107) of nebular condensations, the very process required to evolve solidity from his nebulosity. He speaks of the power of cohesion in the nebulous matter as preceding chemical and other kinds of attraction, not knowing but that the existence of cohesion involves the existence of the rest.

Professor Lewis supposes that, on the third day, the world was finished so far as to have its seas and lands, mountains and valleys, and urges a general theory of evolutions; yet he thinks that this does not necessarily imply that, at that time, the central body, to which the earth is a satellite, was already in its place. The worlds, on such a view, were not evolved according to the analogy of embryogeny, by eliminating the systems and then their parts; but first the scattered parts, and then these, were afterwards put into systems. Science, as well as reason, most plainly teaches, that if any evolution-theory is to be adopted (and such our author aims at), the former is the true one.

In the Mosaic record it is said that, on the third day, dry land appeared; but nowhere does it announce, like our author, that the land was diversified with mountains and vallies: and neither does science.

It is remarkable, that, in a work on the six days of creation, the author's system should have led him so far away from the record, as to place under the fifth day, both his remarks on the creation of vegetation (the work of the third day), and all he has to say on the quadrupeds or mammalia (the work of the sixth). The convenience of his theory of *life from the waters and earth*, appears to have been, in part, the occasion of it. But is this reason sufficient, in a work entitled "The Six Days of Creation, or the Scriptural Cosmology," by an author who expresses great devotion to the Scriptures? — a work exegetical, profound, claiming to sift the Hebrew, and offered as a contribution to our Biblical literature? Can we be satisfied that the word of God has been sufficiently studied and apprehended, when not even a mention of the creation of quadrupeds is introduced into the chapter on the sixth day?

Besides this, the author doubts, on grounds he so contemns, — scientific grounds—whether the higher kinds of vegetation, if any, were created before the sun. He says : " For the development of these, if not for their origination, there is needed the orderly arrangement of the seasons and the regularly-adjusted light and heat of some great luminary."

Moreover, he mentions no reason for the wonderful fact, that two so diverse creations as that of vegetation and the dividing the land from the seas took place in one day ; nor for the equally marvellous fact, that the creation of quadrupeds took place on the same day with that of man.

On the creation of man, we have the crude speculations that have already been cited (p. 98), a miserable substitute for wisdom that comes from above.

Temptations to remark and criticism follow one, all through the pages of such a work ; there is so much to complain of, in the author's philosophy, his exegesis, his ready way of making the Mosaic record literal or " phenomenal," to suit his theory ; his misapprehension of science, and denunciation of established truth. We therefore have had to cull sparingly, not to run to a tedious length.

Is it not a marvel that a learned Professor should accord, in his cosmogony, with the views of science in all their grander points, and yet lose no opportunity to denounce science : should adopt, with science, the idea of indefinite periods for days, and then pick a quarrel because geologists make the days, he thinks, too long ; should build up a system out of Nature and natural causes, or what he supposes to be natural causes, and still abuse a science that also uses Nature and natural causes, and studies not to stretch those causes beyond what is warranted by direct observation ; should attempt to grasp a subject that requires the highest knowledge of natural possibilities, without the least investigation as to what are the actual powers or capabilities of Nature ? An honest doubt of the conclusions of geologists, in the mind of one who has not pursued the subject, is reasonable enough ; but for such a one, in his acknowledged emptiness, to turn around and charge science or the students of Nature with flippancy and ignorance, is at least to prove

himself a subject meriting psychological investigation. Science, it is true, is so far conceptionless as to clip the wings of fancy in world-making; but it is not a fault that should send her to purgatory.

It can hardly be doubted by our readers that the "Cosmology" of Professor Lewis fails of exhibiting the spirit of the original. And we believe it will soon appear, if not so already, that it indicates no adequate comprehension of the philosophy or divine features of that record. It may be good Platonism; but it is, in our view, neither scriptural theism, nor true naturalism.

Having in our *first part* presented a general sketch of science, its aims and its laws, or the laws of Nature, as a basis of comparison with the opinions of Prof. Lewis, we have considered, in our *second part*, the "Cosmology" brought forward by him as an interpretation of Genesis. It now remains, as our *third part*, to mention those points in which science has thrown light on the Mosaic account; light which could have come from no other source. We pursue this method of meeting the views of Professor Lewis on the legitimate uses of science in Biblical interpretation, rather than that of direct argument and criticism.

As introductory, we would first offer a few thoughts on the authority of the Mosaic record, and then endeavor to correct some misunderstandings with respect to geology.

Since geology began to be a science, believers in the Sacred record have gradually divided off into four classes.

1. Those who hold, on exegetical grounds, that the account in Moses admits only of a strictly literal interpretation, and denounce all geological conclusions.

2. Those who take the same view of the record, but admit in the main the results of geological research, and regard the record as a myth, correct in making God the creator, and in the general notion of progress.

3. Those who adopt a liberal interpretation of the record as most consistent with its spirit and truth, and believe both the written word and the testimonies which are gathered from the study of Nature.

4. Those who adopt the liberal interpretation of the last, but with denunciations of geology, while at the same time accepting its main conclusions.

The truthfulness of the Mosaic record is admitted by all the classes here referred to, excepting the second. These, on the ground that the early part of Genesis bears evidence of being a collection of two or three distinct accounts, suppose that Moses adopted that particular ancient or traditional story which acknowledged God as the Creator; and they do not insist upon its being correct in details. It would at first seem as if this liberality of view were a consequence of a firm and well-defined belief in the deductions of science. This is so with some; but with many, it is just the other way: there is a vague opinion that geological facts cannot be set aside; and as the literal rendering of the Hebrew, in their view, is also inflexible, they consequently let the record go, — we can hardly say, as the least of two evils. They thus obtain a sufficient ground for rejecting all attempts to reconcile science and the Bible.

The fact, if it be a fact, that the account was a tradition which Moses adopted, would not necessarily prove it incorrect in any of its statements. The acts in creation had no human witness, and therefore the tradition either was originally from the Being who had before given man a living soul, or else it was only a human conception of world-evolution. If the former, it might still be, throughout, truthful; while at the same time we should naturally infer, in the case of such a tradition, that the exact literality might yield a little to research, provided the spirit of the whole were sustained. If the latter, then the whole is hardly better than a fable, except the grand pervading truth — God in creation. In this last case, the Divine signet is stamped on a false or suspicious document, and thus opens the Sacred Book — false not in mere drapery, for the account is peculiarly free from adjuncts or symbols, presenting a series of definite assertions as to the acts of the Deity himself. Admitting the account as thus untrustworthy, science becomes the only true record of the history of creation; and its facts should hence

have a vastly enhanced interest, especially to the religious world.

But we do not believe in this fabulous origin, as we show beyond. And if but little flexibility is allowed to the Hebrew by the exegetical student, the record will stand firm, sustained by Nature and the God of Nature. We call it flexibility; yet we have the authority of some learned Biblical scholars for concluding that the liberal rendering, required by science, is the only correct rendering of the original words of Moses. Our own faith in both records is the more confirmed, the deeper we pursue our investigations.

We cannot believe that Moses had a full comprehension of the events he narrates, any more than the Jewish prophets, of the spiritual kingdom of Christ which they foretold. The account is but an epitome of creation, in a few comprehensive enunciations. The details God had before inscribed in the earth itself; and science fulfils its end in reading those records and receiving the lessons they teach.

Accepting the account in Genesis as true, the seeming discrepancy between it and geology rests mainly here: geology holds, and has held from the first, that the progress of creation was mainly through secondary causes; for the existence of the science presupposes this. Moses, on the contrary, was thought to sustain the idea of a simple fiat for each step. Grant this first point to science, and what further conflict is there? *The question of the length of time*, it is replied. But not so; for if we may take the record as allowing more than six days of twenty-four hours, the Bible then places no limit to time. *The question of the days and periods*, it is replied again. But this is of little moment in comparison with the first principle granted. Those who admit the length of time and stand upon days of twenty-four hours, have to place geological time *before* the six days, and then assume a chaos and reordering of creation, on the six-day and fiat principle, after a previous creation that had operated for a long period through secondary causes. Others take the days as periods, and thus allow the required time, admitting that creation was one in progress, a grand whole,

instead of a *first* creation excepting man by one method, and a *second* with man by the other. This is now the remaining question between the theologians and geologists; for all the minor points, as to the exact interpretation, of each day, do not affect the general concordance or discordance of the Bible and science.

On this point, geology is now explicit in its decision, and indeed has long been so. It proves that there was no return to chaos, no great revolution, that creation was beyond doubt one in its progress. We know that some geologists have taken the other view. But it was only in the capacity of theologians and not as geologists. The Rev. Dr. Buckland, in placing the great events of geology between the first and second verses of the Mosaic account, did not pretend that there was a geological basis for such an hypothesis; and no writer since has ever brought forward the first fact in geology to support the idea of a rearrangement just before man;—not one solitary fact has ever been appealed to. The conclusion was on biblical grounds, and not in any sense on geological. The best that Buckland could say, when he wrote twenty-five years since, was, that geology did not absolutely disprove such an hypothesis; and that cannot be said now.

It is often asserted, in order to unsettle confidence in these particular teachings of geology, that geology is a changing science. In this connection, the remark conveys an erroneous impression. Geology is a progressing science, and all its progress tends to establish more firmly these two principles. (1) The slow progress of creation through secondary causes, as explained, and (2) the progress by periods analogous to the days of Genesis.[1]

[1] The various uses of the word *day* in the Mosaic account of creation are not all mentioned by Prof. Lewis. *First*, in verse 5, the *light* in general is called day, the darkness, night. *Second*, in the same verse, *evening and morning* make the first day, before the sun appears. *Third*, verse 14, day stands for *twelve hours* or the period of daylight, as dependent on the sun. *Fourth*, same verse, in the phrase "days and seasons," day stands for a period of *twenty-four hours*. *Fifth* at the close of the account, in verse 4, of the second chapter, day means the *whole period of creation*. These uses are the same that we have in our own language.

What other points science in its present state establishes or elucidates, we shall now consider. The best views we have met with on the harmony between Science and the Bible, are those of Prof. ARNOLD GUYOT, a philosopher of enlarged comprehension of nature and a truly christian spirit; and the following interpretations of the sacred record are, in the main, such as we have gathered from personal intercourse with him.[1]

The first thought that strikes the scientific reader is the evidence of Divinity, not merely in the first verse of the record, and the successive fiats, but in the whole order of creation. There is so much that the most recent readings of science have for the first time explained, that the idea of man as the author becomes utterly incomprehensible. By proving the record true, science pronounces it divine; for who could have correctly narrated the secrets of eternity but God himself?

Moreover, the order or arrangement is not a possible intellectual conception, although we grant to man, as we must, the intuition of a God. Man would very naturally have placed the creation of vegetation, one of the two kingdoms of life, after that of the sun, and next to that of the other kingdom of life, especially as the sunlight is so essential to growth; and the creation of quadrupeds he would as naturally have referred to the fifth day, leaving a whole day to man, the most glorious of all creations. Prof. Lewis, in making no allusion to the creation of quadrupeds on the sixth day, writes as if it were a mistake that this was not so done. Man, again, would never have separated the creation of light so far from that of the sun, to us the source of light; neither would he have conceived of the creation of the firmament, as that word is usually understood, and was under-

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The meaning of the words "evening and morning" we believe to be correctly given by Prof. Lewis.

[1] The views of Prof. Guyot have been presented at some length in this journal by Rev. J. O. Means (numbers for January and April, 1855). They are here brought forward from a different point of view with other illustrations, and additional deductions from the science.

stood by the Jews, without the stars as part of its decoration.

Moreover, there is a sublimity and system in the arrangement, and a far-reaching prophecy, to which philosophy could not have attained, however instructed.

The creation, in the first place, consists, according to the record, of two great periods; the *first three* days constitute the *inorganic* history, the *last three* days, the *organic* history of the earth.

Each period begins with LIGHT; the *first*, light cosmical; the *second*, light to direct the days and seasons on the earth.

Each period ends in a day of two great works. *On the third day*, God *divided the land from the waters;* and he "saw that it was good." Then followed a work totally different, *the creation of vegetation*, the institution of a kingdom of life, a work more unlike that of the former half of the same day than those of any two whole days preceding; as much a new creation when expressed in a sea-weed, as in an oak or apple-tree. So, *on the sixth day*, God created *the quadrupeds* or Mammalia, and pronounced his work "good;" and as a second and far greater work of the day, totally new in its grandest element, he created MAN; and he then pronounced his creation "very good."

There is here no chance parallelism; for God neither in his word or works can be charged with accidental or unmeaning harmonies.

Vegetation, while for physical reasons a part of the creation of the third day, since its main end is physical, was also prophetic of the future, the true organic period, in which the progress of life was the grand characteristic. So again, man, while like other mammals in structure, even to the homologies of every bone and muscle, was endowed with a spiritual nature, which looked forward to another period, that of spiritual existence and immortality. Thus the last day of each great period included one work typical of the period, and the other, while essentially of the period, prophetic of the future.

Surely, philosophy never could have attained to such a

glorious scheme. What now are the special points which God's testimonies in nature have made clear?

I. *The progress of creation mainly through secondary causes.* Time was lengthened back by geology to ages unmeasured. This had before been suspected: geology made it positive knowledge.

II. *The fact that the days of Genesis were as many long periods*, the progression of physical changes and of living beings, being, on this principle, in harmony with the Bible record. The Infinite God worked not by man's time-piece, or by the roll of a ball in space, counting the twenty-four hours, but in his infinitude and eternity, he directed events through the passing ages as if those ages were but moments.

We may remark here, that science explains, and general history also, what we must understand by epochs or periods in history. We learn that the importance of an epoch is generally inversely as its length, or rather, has no necessary relation to length of time. Take the life of a plant, for example: there is the epoch of the stem, that of the flowering, that of the fruit; the first much the longest, and yet the least important in itself. Then, again, the incipient stages of an epoch, are deep in preceding time: the changes leading toward it are at work, and now and then an event strikingly betokens the coming age, and is in fact a characteristic of that age coming up through the darkness of earlier time, foretelling or announcing the future. All history is alike in this; geological history is full of it. An age is marked by its great features, by the cresting of some characteristic; while its limits — its beginning and end — may be, and usually are, indefinite. It is thus that vegetation in the organic division of time was prophetic of the period when life should be the glory of the world.

As to the actual length of periods, geology gives us no definite knowledge.

III. *The true principles or law of development or evolution in nature.* We observe, as Agassiz has well illustrated, that the development of a living being brings out the profounder distinctions and afterwards those more external. First, in the

growing germ or egg appears a character that enables us to note the class; then, that of the order; then, that of the tribe, family, genus, in succession; and finally, that distinguishing the species. It is an individualizing process. We have already alluded to this subject on a preceding page.

Taking the earth alone as an example, geology proves that it was, at one time, a fiery ball in space; and, of course, with no more distinction of parts than in a germ. Then, dry land and seas appear; but the land is of small extent and without its mountains, the waters are all salt, and the climate is one over the whole sphere, the tropics reaching to the poles, for the same tribes of plants covered all zones, even to Melville Island and Spitzbergen. At a much later period, the mountains begin to enlarge, the dry land to expand, and gradually, as time rolls on, a temperate climate settles about the poles; the tribes of animals also become more localized. Then, in the last age before man, the continents take their full breadth, the Alps and Pyrenees are born, and other mountains attain their majestic dimensions; the rivers consequently multiply and increase in magnitude and in their erosive power, and valleys are everywhere formed in great diversity of beauty; moreover, the zones of climate become nearly like our own, and every region of the globe has its peculiar Fauna and Flora and temperature. Finally, the features, and climates, and life, attain all their present variety, as man appears to take his place at the command of his Maker. Thus the earth's features and functions were gradually individualized. The subject is illustrated also in various details in the organic history of the globe, to which we briefly allude beyond.

IV. *The universe one, in system and origin.* Threads of light and attraction bind the universe in one, proving an essential unity in the nature and laws of matter. Attraction of gravitation is the fundamental force of matter; and since the law is, in fact and ratio, the same here as in remote space, we may with reason conclude that matter is everywhere essentially the same, now and from its first existence; for the present system of the universe would be annihilated by a change in this law, and therefore it was begun when the law

was established. Bodies possessed of cohesion, necessarily have gravitation; and hence a general identity as regards attraction of cohesion is involved in the identity of gravitation. Light being dependent on vibrations, as science has shown, and these vibrations a result of molecular action, therefore, since precisely the same rate of vibrations and identical characteristics belong to the light of the stars, we have proof of the profoundest significance and of the most precise character, as to the identity of all matter in its general laws. Thus it is literally inscribed on nature that, CREATION IS ONE, GOD IS ONE, THE UNIVERSE ONE.

V. *Light necessarily the work of the first day—the signal of creation begun.* From the recent results of science we know that light is dependent not merely on molecular vibrations, but on vibrations of a certain requisite rate; and also that it is produced only by molecular disturbance, action, or combination; it is a result of chemical or molecular change, and is no independent entity. Without mutual molecular action there could be neither heat nor light. Matter in such an inactive, forceless state, would be literally dark, cold, dead. But let it then be endowed with intense attraction of different degrees or conditions, and it would produce light as the first effect of the mutual action begun.

The command "Let light be," was therefore the summons to activity in matter. The Spirit of God moved or brooded over the vast deep, an abyss of universal night, and light, as the initial phenomenon of matter in action, flashed instantly through space, at the fiat of Deity. Thus science, in its latest developments, declares as distinctly as the Bible, that "on the first day light was."

Light in its veriest universality, must have been the light created, as light is one and the universe one; and not light about the earth, a little satellite to the sun.

VI. "*The beginning*," *the actual beginning.* In the fact that light must have been the first phenomenon in creation begun, and that the universe is one in history, we have all needed evidence that Moses meant "in the beginning," where he so asserts.

"The heavens and the earth," as before stated, is obviously a comprehensive expression for all existence — then a lifeless existence in the extremest sense. The earth was not the earth in defined outline; for, if we may take our translation as correct (and Professor Lewis and others give it the preference), it was "without form, and void," actually formless, and merged in the great "deep," over which the Spirit of God afterwards brooded.

VII. *The earth gradually brought to a condition in which dry land and seas existed.* Geology, as we have observed, has taught that the earth was once in complete igneous fusion; and this would imply a heat at the surface equal at least to that of melted iron. Granting this, there are conditions of its waters and atmosphere, and of its rocky mass, which may be partly followed out; and when we know better than now all the effects of heat on the elements and their compounds, we may perhaps be able to write out the history of those times of chaos. It obviously involved a gaseous condition of the whole ocean, whose waters, if now placed evenly over the sphere, would make a layer averaging two miles in depth. From this state, there would have been a passage to successive stages of condensation, as the cooling went on. Finally, the waters would descend and envelop the surface; and afterwards, by unequal contractions of the still cooling earth, the dry land would have appeared.

As it would have required a temperature of at least 500 or 600 deg. Fahrenheit to have retained so much water in the state of vapor, the surface of the earth could not have been much below this, when the ocean descended to its place. It was still a highly heated earth and ocean, and the atmosphere must have been dense and murky with foul vapors. In Job there is a sublime description evidently of this period (38: 8—10). Jehovah says: "Who shut up the sea with doors . . . when *I made the cloud the garment thereof and thick darkness a swaddling-band for it*, and brake up for it my decreed place, and set bars and doors, and said, Hitherto shalt thou come and no farther, and here shall thy proud waves be stayed." From such a state, the earth gradually emerged,

that garment of cloud slowly dissipating. The tides and waves rolled around the sphere in ceaseless motion; and, however incredible it appears, we can point out the strata that were made by that ancient ocean. Geology has brought to light rocks of great thickness, without traces of fossils, and many of them crystalline, which belong to time preceding the creation of animals, after the descending of the waters to the surface. They are called the *Azoic* rocks, or rocks of the Azoic age, because no traces of animals occur in them. Geology proves, too, that before animal life began, large areas of these rocks were dry land, over North America from Labrador westward, and we may almost map out the "dry land" on this hemisphere, which is announced on the *third day*.[1]

VIII. *Vegetation part of the physical creation.* The introduction of vegetation on the third day, was one of the mysterious facts in creation until the recent revelations of science. Now we know that the prime mission of vegetation is physical, the removal from the atmosphere of a deadly gas, carbonic acid, and the supply to it of one eminently a supporter of life, oxygen. This it accomplishes by the simple process of growth; upon this great end, its vital functions and structure are based; this single criterion distinguishes all plants from animals. Feeding animals and giving joy by its beauty to the human soul are only concomitant ends of vegetation.

Moses in announcing the creation of vegetation describes plants in general. But the institution of the plant-kingdom was the great event; and if plant-life came forth first in the sea-weed, it was still life, a new feature to the progressing world. According to the records in the rocks, vegetation was for a long age only sea-weeds; then in the coal-period,

[1] We have omitted any special reference to the *second day*, as neither geology nor general science, apart from astronomy and general reasoning, afford much aid in interpreting the account. The step of progress was one between that of light through universal space on the first day, and the separation of the lands and seas on the third. The event of the highest character in that interval, that marking a grand epoch in terrestrial time, was the elimination or separation of the earth itself from the "deep" or "waters," (admitted to mean "fluid" in its most extended sense). See Prof. Guyot's views on this subject, in the article in this journal, for April last, p. 327.

flowerless trees, along with the pine tribe (coniferæ) which are almost flowerless; and as the last age before man was about to open, trees of our common genera, oaks, elms, etc., and also the palms, began to diversify the earth's surface.

The proof from science of the existence of plants before animals is inferential, and still may be deemed satisfactory. Distinct fossils have not been found: all that ever existed in the azoic rocks having been obliterated. The arguments in the affirmative are as follows:

1. The existence of limestone rocks among the other beds, similar limestones in later ages having been of organic origin; also the occurrence of carbon in the shape of graphite, graphite being, in known cases, in rocks a result of the alteration of the carbon of plants.

2. The fact that the cooling earth would have been fitted for vegetable life for a long age before animals could have existed; the principle being exemplified everywhere that the earth was occupied at each period with the highest kinds of life the conditions allowed.

3. The fact that vegetation subserved an important purpose in the coal-period in ridding the atmosphere of carbonic acid for the subsequent introduction of land animals, suggests a valid reason for believing that the same great purpose, the true purpose of vegetation, was effected through the ocean before the *waters* were fitted for animal life.

4. Vegetation being directly or mediately the food of animals, it must have had a previous existence. The latter part of the azoic age in geology, we therefore regard as the age when the plant-kingdom was instituted, the latter half of the third day in Genesis. However short or long the epoch, it was one of the great steps of progress.

IX. *The creation of the sun on the fourth day.* By arguments already mentioned, based on the oneness of the universe in origin, the sun, moon and stars are shown to have had their places, when the earth was established. But through a prolonged period, as has been remarked, the earth was shrouded in its own vapors, and warm with its own heat, and there was therefore no sun or moon, days or

seasons. Whenever the sun first broke through the dense clouds, it was a day of joy to the world, standing out as one of the grand epochs in its history.

The sun is almost the heart and brain of the earth. It is the regulator of its motions, from the orbital movement in space, to the flow of its currents in the sea and air, the silent rise of vapors that fly with the winds to become the source of rivers over the land, and the still more profound action in the living growth of the plant and animal. It is no creator of life; but through its outflowing light, heat, and attraction, it keeps the whole world in living activity, doing vastly more than simply turning off days and seasons. Without the direct sunlight, there may be growth, as many productions of the sea and shady grounds prove. But were the sun's face perpetually veiled, far the greater part of living beings would dwindle and die. Many chemical actions in the laboratory are suspended by excluding light; and in the exquisite chemistry of living beings, this effect is everywhere marked: even the plants that happen to grow beneath the shade of a small tree or hedge in a garden evince, by their dwarfed size and unproductiveness, the power of the sun's rays, and the necessity of this orb to the organic period of the earth's history.

The sun therefore leads off, not only in fact, but with peculiar grandeur and aptness, the organic history of the globe.

Thus, at last, through modern scientific research, we learn that the appearance of light on the first day and of the sun on the fourth, an idea foreign to man's unaided conceptions, is as much in the volume of nature as that of sacred writ.

X. *The invertebrates, fishes, reptiles, and birds, the earlier animal creations.* Geology has opened out the fact, that the earliest animals and plants of the globe were wholly water species. There was a long *marine era*, the lands small, the seas nearly universal, the continents marked out it is true in their grand outline, but only partly emerged; the animals only the inhabitants of the seas, as molluscs, corals, and fishes.

This was followed by a *semi-marine*, or *amphibian era*, as

it may be called, when land-plants took possession of the dry land, producing in its earlier half the coal era: but still the continents were at least half the time more or less submerged. Reptiles and birds were then the dominant animal types.

As God has recorded in the rocks by the burial of these races in their successions, so he has written in His word. On the fifth day, He said: "Let the *waters* bring forth," by *waters* implying apparently the marine or amphibian character of the species of life; and then, the account adds: "The waters brought forth *abundantly*," while the rocks testify also to swarming myriads in the seas. The species with few exceptions were oviparous. Prof. Bush shows that the "great whales" were as correctly *reptiles*, the same word *tannim* being used for *dragon* in Ezek. 29: 3, where the figure is drawn from the crocodile of the Nile; also that the word for *fowl*, means rather *flying thing*, whether insect, bird, or flying reptile, all of which occur in this era. He says moreover that the clause in verse 20, translated "and fowl that may fly above the earth" may be as correctly translated *and let the fowl fly above the earth;* so as to disconnect it from the clause, "Let the waters bring forth:" thus it stands in verse 22.

The harmony of geology with Genesis could not be more exact.

XI. *The creations of the tribes not simultaneous but successive, and occurring at many different times, after more or less complete exterminations.* The records in the rocks declare that these creations came not forth all at once, but in long progression. There was an Age when Molluscs (of which shell-fish, snails, and cuttle-fish are examples) were the dominant race, having as associates corals, crinoids, and trilobites. The earth, we may believe, was yet too warm, and the atmosphere too impure for more exalted forms. This was the *Silurian age* of geological science.

There was next an Age when Fishes first filled the seas, the *Devonian* of geology. Then another, when Amphibians (the inferior group of reptiles, including frogs and salaman-

ders, related to fishes in having gills when young) commenced, and land-plants were first in exuberant growth, the *Carboniferous age* (the land-plants, as stated, cleansing the atmosphere from carbonic acid for land animals). Then followed an Age in which true reptiles increased in numbers and diversity, by multiplied creations, until there were reptiles larger than whales in the water, immense leviathan reptiles on the land, and flying reptiles in the air, so that each of the elements was taken possession of by these scaly tribes. This was the *Reptilian age*. In its progress, reptiles passed their climax, and before its close, commenced their decline; the race, since then, has been a comparatively feeble one.

Moreover, in each of these Ages, there were many distinct creations succeeding to exterminations of previously existing life. Through the Silurian, Devonian, Carboniferous and Reptilian Ages in America, the fifth day of Genesis, *fifteen times* at least the seas were swept of their species, so that, in the rocky folios of the succeeding epoch, not a species of the former epoch occurs, or only half a dozen or so out of hundreds. After each, life was again reinstated by the Creative Hand, life in all the departments that had thus far been introduced to the globe, new mollusca, new corals, new crinoids, new trilobites; and if the Age of Fishes were in progress, new fishes also, and so on; making a complete creation for the time. Even in the Age of Fishes alone (the Devonian age), there were *four* such revolutions in America, with new creations throughout. Moreover, there were many partial destructions and restorations at other times. These exterminations can be proved, in many cases, to have been produced, either by the escape of heat, through fissures, from the earth's interior, or the elevation of the sea-bottom to dry land, or some convulsion in the earth's crust. They were, in general, connected with the earth's physical history.

Recapitulating the geological Ages mentioned, and adding those following, they are (naming them, as has been done by Agassiz, from the dominant type):

I. the Age of Molluscs, or the Silurian; II. the Age of Fishes, or the Devonian; III. the Age of Coal-plants and

Amphibians, or the Carboniferous; IV. the Age of Reptiles, including the periods between the Coal and the Tertiary; V. the Age of Mammals, or the Tertiary and Post-Tertiary; VI. the Age of MAN. The progress of Vegetable Life affords: *first*, the Age of Algæ or Sea-weeds, corresponding to the Silurian and Devonian; *second*, the Age of Flowerless Trees (Acrogens) and Coniferæ, or the age of Coal-Plants; *third*, the Age of Dicotyledonous Plants, or our common trees (oaks, elms, etc.), beginning just before the age of Mammals.

XII. *A gradual elevation of the successive races involved in the gradual refrigeration of the earth, as also in its other steps of physical progress.* The whole plan of creation had evident reference to MAN as the end and crown of the Animal Kingdom, and to the present cool condition of the globe, as, therefore, its most exalted state. It is hence obvious, that progression in the earth from a warmer to a cooler condition, necessarily involved progression from the lower to the higher races, such as actually took place. This cooling, therefore, implied almost necessarily the complete extinction of some earlier races, fitted for earlier time, as well as of species. The whole fifth day (using the term in Genesis) until its later epochs, was a time of warm climate from the equator to the poles. Not a species of the thousands in those ages now exists. Species and genera appeared and disappeared as time moved on: the last trilobite lived in the Carboniferous seas, and the last Lepidodendra in the forests of the Carboniferous continents; the last ammonite, flying reptile and swimming saurian existed in the Reptilian age, when molluscs as well as reptiles passed their prime, both as to numbers of individuals and rank of species. Even the fishes bear distinctly, in their bodies, the marks of the particular part of the fifth day in which they lived: for they first appear in the Devonian age with the spinal column elongated quite to the extremity of the upper lobe of the tail; and afterwards it becomes less and less elongated until the middle of the Reptilian age, when, for the first time, species occur with the body cut off square behind, as in existing species; moreover, the old type of tail disappears, and almost

completely too the Ganoid tribe of fishes, in which it was so striking a characteristic. Thus the world took its successive steps onward, towards the Golden Age, in the then distant future. The earlier races were of lower types, not because the Creative Hand was weak, but for the reason that the times, that is the temperature and condition of the globe, were just fitted, in each case, for the races produced, and the progress of the plan of creation, correspondingly, required it.

As between the hot equator and the frigid zones, tribes now have their limits in geographical distribution, so in geological time, between the warm Silurian age and the cool present, there was a localization of groups in time, a chronological distribution,—an increase and period of maximum at different epochs along the Ages. The Reptilian and Molluscan types attaining their maximum in the Reptilian age, are examples. A few genera reach from the very first dawn of life to the existing period: they are continuous lines, binding creation in one. This oneness also appears most strikingly in the fact that hardly a fragment of a fossil is taken from the oldest rocks that is not at once as well understood as if it were from an existing species.

The intervals of rest in "self-existent" nature, which Professor Lewis speaks of, are not in the records of the earth. The longest suspension of life in North America took place, as nearly as we can learn, between the Coal period and the Middle Reptilian. Moreover, the epochs of revolution in Europe and America were, in general, not contemporaneous; and this implies merely a non-contemporaneity in the convulsions or oscillations of the earth's crust in the two hemispheres.

XIII. *System of life-evolution.* The facts gathered from nature teach us:

1. That species have not been made out of species by any process of growth or development; for the transition-forms do not occur.

2. That the "original divine power" did not create a generic or universal germ from which all subordinate genera and species were developed; for, with any such system of

evolution, the Creator would have been incompetent to complete the creation begun; each revolution would have frustrated every new effort.

3. That the evolution or plan of progress, was by successive creations of species, in their full perfection. After every revolution, no imperfect or half-made forms occur; no backstep in creation; but a step forward, through new forms, more elevated in general than those of earlier time.

4. That the creation was not in a lineal series from the very lowest upward. The four sub-kingdoms of animal-life, the Radiate, Molluscan, Articulate, and Vertebrate, early appeared in some of their representatives; and the first three almost or quite together. The types are wholly independent, and are not connected lineally, either historically or zoologically; and this is a general principle with regard to subordinate groups. The earliest species of a class were often far from the very lowest, although among the inferior. The gigantic saurians appeared before turtles and serpents; trilobites were superior to many crustaceans afterwards created; and the fish that began the Vertebrata, were powerful species, even superior in attributes of life, though not in type, to some existing Amphibians.

5. That the creation of life was the unfolding of a plan, which involved distinct archetype enactments, and, subordinate to these, and in harmony with them, expressions of purposes or ideas of a less and less general character. The four sub-kingdoms of animal life were the four archetype enactments: they limited the development of the animal creation to these four directions; and every new group came forth in subordination to these established types. So the subordinate groupings, classes, tribes, etc., have the same relation to the groups under them.

6. That the development of the plan of creation, while by successive creations, was in accordance with the law of evolution, as Agassiz has explained, that is, progress from the simple to the complex, from comprehensive unity to multiplicity through successive individualizations. The institution of the Vertebrate type in the memberless fish, embraced in

its idea all those parts and organs, external and internal, which were afterwards brought out, and which have their highest individualization, in man; so that in the bony structure, for example, we may trace the homologies between the human skeleton and the primitive fish-type. The unfolding was, in some groups, a general rising in grade, until the time of maximum, as in the Reptilian type; but embraced expansions both upward and downward, that is, to superior and inferior tribes. In many cases, the original or earliest group was but little inferior to those of later date, and the progress was towards a purer expression of the type. Thus the earliest fishes had reptile teeth, a bony coat of mail, and other reptilian characteristics, foreshadowing the Reptile type afterwards introduced. In the unfolding of the type, the reptilian features were lost, the ancient race became almost wholly extinct, and gradually the fish type came out in its purity and full diversity. This is one of numerous examples of this kind.

The Molluscan type was unfolded, in all its grand divisions in the Silurian or Molluscan age. The Articulate type, on the contrary, appeared then only in the inferior water-species, crustaceans and worms; and gradually, as time moved on, one grand division after another was evolved, until the age of Man, the period of their greatest diversity. A reason for this difference consists in the fact that Articulates are, like Vertebrates, largely land species. Moreover, every new diversity of climate, soil, plant, or animal, enlarged the field for insect life.

7. That hypotheses as to the precise mode of creating a species are presumptuous. D'Orbigny, a distinguished geologist of France, in his Geology (1851, vol. II., p. 251), says well: "Quelle est la force créatrice qui a eu cette toute-puissance si extraordinaire? Ici nous devons confesser l'impossibilité complète dans laquelle nous trouvons de répondre à aucune de ces hautes questions. Il est des limites que l'esprit humain ne peut franchir, des circonstances où l'homme doit s'arrêter et se borner à admettre les faits qu'il ne peut expliquer."

XIV. *The revolution closing the Reptilian age in geology a universal one.* Although the catastrophes in the earth's history were seldom universal, that closing the Reptilian age swept both Europe and America alike, and, as far as we know, the whole earth. Its destruction of the life of the Cretaceous period (the last of the Reptilian age) was complete, with scarcely an exception. Thus geology and the Bible both mark the close of the *fifth day.* After such a devastation, the new creation began, that of Mammals or quadrupeds: not, be it understood, of Mammals alone, for all the lower tribes had their various representatives also, by the same creation, from molluscs and corals to fish and reptiles. All, by their new forms, express the character of the age. The climates of the earth, as this age of Mammals opened, were, for the first time, widely diversified; yet the facts show that they were not as cool as now, until the age had half elapsed.

XV. *The creation of Mammals introducing a new element into the world.* The type of animal life which began with this age, the *sixth day*, was that in which the earth was to reach its highest destiny. It was the full establishment of that special type of Vertebrates that was at last to be exalted by the endowment of a soul; that, in which the mutual dependence of the parent and young, indicated in the term *mammalia*, is its grand feature, the principal means, in this age of Man, of cultivating those affections which bind society together and man to his Maker. There is hence the highest beauty and philosophy in the Mosaic record, independent of its historical facts, in thus separating the Mammals from the other Vertebrates.

Some small insect-eating Mammals appeared in the age of Reptiles. They were few (four species have been found) and weak, in striking contrast with the huge Saurians that filled the seas, earth, and air in that age. They have been well called prophetic types, announcements, as has been already explained of the true age of Mammals next to open in its full grandeur. Such seeming exceptions are in fact

part of the system of progress, and afford no objection to the reality of the great Ages.

XVI. *Progress by revolutions, and by successive creations in the age of Mammals; but the revolutions diminishing in extent as the age of Man approached.* The age of Mammals had its revolutions like the Reptilian age and those preceding; but they become less and less general, and the continents more and more stable, and modern in outline and features. The *marine* and *amphibian eras* of the globe had passed; and this was the commencement of the *continental era.*

The quadrupeds did not all come forth together. Large and powerful Herbivorous species first take possession of the earth, with only a few small Carnivora. These pass away. Other Herbivora with a larger proportion of Carnivora next appear. These also are exterminated; and so with others. Then the Carnivora appear in vast numbers and power, and the Herbivora also abound. Moreover these races attain a magnitude and number far surpassing all that now exist, as much so indeed, on all the continents, North and South America, Europe, Asia, Africa, and Australia, as the old mastodon, twenty feet long and nine feet high, exceeds the modern buffalo. Such, according to geology, was the age of Mammals, when the brute species existed in their greatest magnificence, and brutal ferocity had free play; when dens of bears and hyenas, prowling tigers and lions far larger than any now existing, covered Britain and Europe. Mammoths and Mastodons wandered over the plains of North America, huge sloth-like Megatheria passed their sluggish lives on the pampas of South America, and elephantine Marsupials strolled about Australia.

XVII. *A dwindling of the race of Mammals as the age of Man approached.* As the Mammalian age draws to a close, the ancient Carnivora and Herbivora of that era all pass away, excepting, it is believed, a few that are useful to man. New creations of smaller size peopled the groves; the vegetation received accessions to its foliage, fruit-trees and flowers, and the seas brighter forms of water-life. This

we know from comparisons with the fossils of the preceding Mammalian age. There was, at this time, no chaotic upturning, but only the opening of creation to its fullest expansions: and so in Genesis, no new day is begun, it is still the *sixth day.*

The continents long before had had their marked characteristics: the Oriental (including Europe, Asia, and Africa) as the continent of *Carnivora*, the highest mammals; North America, of *Herbivora*, a tribe inferior to the Carnivora; South America, of the sloth and armadillo tribes (*Edentata*) still lower in rank; Australia, of the Kangaroo tribe or *Marsupials*, the lowest of all quadrupeds; for these were severally the characteristic races of the continents in the Mammalian age. As the age of Man opens, North and South America and Australia were still essentially the same in their tribes of Mammals, though with new and smaller species; there is no sign of progress. The Oriental lands, on the contrary, which had so prominently taken the lead in the age of Mammals, and even through the whole Reptilian age preceding,—since the species of animals in Europe as indicated by the fossils, were ten times more numerous than in North America,—may be said to have been marked out for the Eden of the world, ages previous to man's creation.

XVIII. *Man, the new creation.* In the living beings of former ages, there had been intelligence and a low grade of reason, affections as between the dam and her cub, and the joyousness of life and activity in the sporting tribes of the land. But there had been no living soul that could look beyond time to eternity, from the finite towards the infinite, from the world around to the world within and God above. This was the new creation, as new as when life began; a spiritual element as diverse from the life of the brute as life itself is diverse from inorganic existence.

The *first* great period of history, was the period of mere material existence and physical progress. Its beginning was far away in the dim indefinite past, when light announced the work of progress begun; and even beyond, in the forceless matter of preceding time; after many changes and

evolutions, it blossomed in the lands and seas and vegetation of the third day. The *second* great period was the period of life and organic progress. Its germs are traced in the vegetation of the former period; but the light of the sun first gave vigor to the growth, and after various developments progressing through long ages, it finally blossomed in the Mammals and man of the sixth day. The *third* great period is the more exalted period of spirit and spiritual progress; whose germs are even now expanding in the soul of man; but whose flowers and fruit will appear, only in time to come. The great evolutions of time are thus so closely in accordance with the evolutions in a living being, although all is by the direct power and wisdom of God as before explained, that we comprehend the system best in language recognizing the parallel relations and oneness of principle.

XIX. *Man the last creation: The day of rest.* Science has no evidence that any living species have been created since the appearance of man on the globe. All facts in nature accord with the Scripture record, that man was the last of the grand series. Ages and ages had rolled by, the world had, step by step, been fitted up, and life had passed through its long succession of forms, ever increasing in rank, until at last man stood up erect, fitted to subjugate the mightiest energies of nature, to read the records of infinite intelligence, to embrace a universe in his sympathies, and reciprocate the love of Heaven. Creation thus ended. God pronounced upon it his benediction and rested from all his work. Analogy with the other days of Genesis, in the light of geology, certainly would lead us to regard that seventh day, not as a simple twenty-four hours, but the period of rest still in progress.

The two records, the earlier revelation and the later, are thus one in their sublime enunciations of the history of creation. There is a like grandeur in the progress of the ages. They both contain conceptions infinitely beyond the reach of the human intellect, and bear equal evidence of their divine origin. The "grand old book of God still stands," and this

grand old earth, the more its leaves are turned over and pondered, the more will it sustain, enlighten, and illustrate the sacred word. The two are independent inscriptions, written in lines of light by the same Sun of righteousness; and the more deeply they are studied and loved for their truths, the higher may we rise towards the effulgence of their eternal source. The universe and the Bible are consecutive parts of one glorious volume; the *former* teaching of infinite harmonies, coming up from the deep past, and of man's relation through Nature to God; the *latter* of man's relation through his own soul to God, and of still loftier harmonies in the eternal future: the *first part*, telling not only of the wisdom and power of God, but also of man's exaltation, at the head of the kingdoms of life, the being towards whom, with prophetic eye, all nature was looking through the course of ages, preparing his earthly abode, arranging every ridge, and plain, and sea, and living thing, for his moral and intellectual advancement, and with so much beneficence that man, when he came to take possession of the domain, found everywhere lessons of love and adoration, and read in his own exaltation a hope, though a trembling hope, of immortality; the *second part*, after a chorus epitomizing the former revelation, pursues its closing thought, Man in his relation to his Maker, makes that hope of immortality sure, and points out the way of life, by which he may enter into everlasting communion with God his Creator and Redeemer. If students of nature fail of that way of life, it is not that science is evil, but man fallen.

PROSPECTUS

OF THE

BIBLIOTHECA SACRA

AND AMERICAN

BIBLICAL REPOSITORY.

1856.

THIS Periodical is edited by Prof. E. A. Park and Mr. S. H. Taylor, of Andover, Mass.; aided by Professors Robinson, Day, Allen, Stowe, Barrows, Phelps, Shedd, Brown, Putnam, and Drs. Davidson of England and Alexander of Scotland.

It will be the constant aim of the Editors and of the gentlemen who assist them, to furnish essays and discussions of sterling and permanent value, so that complete sets of the work will be regarded as an important accession to any library.

Articles of abiding interest will be sought, rather than those of a local, temporary, or merely popular character. Thus will the work be as valuable twenty or fifty years hence, as now. It will aim to meet the demands and to increase the power of the pulpit, by examining a wide range of topics, and furnishing illustrations of Christian truth from the various departments of science.

The publication will embrace Theology in its widest acceptation, as comprehending the Literature of the Scriptures, Biblical Criticism, Natural and Revealed Theology, Church History with the History of the Christian Doctrines and Sacred Rhetoric. Special prominence will be given to Sacred Literature. It will be the aim to procure for every Number two or three Articles at least, explanatory or illustrative of the Scriptures, direct expositions of the text, or discussions in the rich field of Biblical Criticism. Particular facilities in some parts of this department are supplied by American Missionaries resident in Syria and Western Asia, and by travellers in the East. We shall endeavor to enliven the discussions of a more abstract nature by the insertion, in each Number, if possible, of one piece of biography.

To a limited extent, questions in Mental and Moral Philosophy will be discussed, partly on account of their immediate and important

bearing upon Theology, and partly for the sake of the intrinsic value of the questions themselves.

Some attention will also be paid to Classical Literature. Many of our subscribers, and some of our most valued contributors are Presidents and Professors in the colleges. No publication in this country is specifically devoted to the classical languages. They furnish many topics of special interest to the Biblical student and which have important relations to Sacred Literature.

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The union of the Bibliotheca Sacra with the Biblical Repository has excited a general interest both in this country and in England and Scotland. There is not only a large circulation of the American edition, but arrangements have been made to publish the work in Great Britain. The assistance of Drs. Davidson of England and Alexander of Scotland has also been secured in the editorial department. The circulation in this country has been largely increased and the work is placed on a permanent basis; still its usefulness and value depend much on maintaining and extending its American circulation. It is hoped that the friends of the work will not allow it to suffer in this regard.

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W. F. Draper, *Publisher.*

ADDRESS

BEFORE

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

AUGUST, 1855.

BY

PROFESSOR J. D. DANA.

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ADDRESS

OF

PROFESSOR JAMES D. DANA,

PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE YEAR 1854,

ON RETIRING FROM THE DUTIES OF PRESIDENT.

MR. PRESIDENT AND GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: —

IT is a noble object that invites us to these annual gatherings. Leaving the broils of the world to others, we come to contemplate together the teachings of God in nature. We come with faith in that word which is written around and within us, believing in the truthfulness of the revelation, and knowing that he who approaches it with an inquiring, teachable spirit, ever wakeful to the still, small voice, and forgetful of ambitious self, shall find the truth and feel its benign influence. We aim to decipher some new words in the volume of Nature, that we may learn the will of Him who has ordered all things well, and comprehend more fully His laws in the government of the universe.

In the use of this word *law*, as applied to nature, we are often grossly misunderstood. Says a recent writer, somewhat contemptuously, "The philosopher knows no better the cause of the law of gravitation than the ignorant man." The author, in his simplicity, is unaware that laws, not causes, are the end of true philosophy. We seek to study out the method of God's doings in nature, and enunciations of this

his method or will are what is meant by the "laws of nature." If those who look coldly on science knew better its aims, we should hear less of the infidelity of the term *law*, and find fewer infidels or rejecters of that revelation which God has spread out before us.

We know that this is not the only revelation; that another tells man of his duties and responsibilities, of the celestial sympathy which surrounds him, and his immortal destiny, — subjects far beyond the teachings of physical or brute nature. The one is but the complement of the other; the two harmonious in their truths, as in their exalted origin.

Although different in scope, they teach alike humility and reverence. To the vision of science, there is nothing in nature minute or unworthy. It pities the feeling that would turn with contempt from the meanest created thing. For it stops not with mere externals, but distinguishes profound relations and universal laws beneath the surface. Exhibit the leaf of a plant, or an animalcule, under a microscope, to a person of good taste, as the phrase is, and he will appreciate the beautiful coloring and the wonderful forms displayed; for form and color are media of real beauty in nature, and there are eyes enough to admire. But let another look whose mind has been deeply imbued with science, and profounder beauties open to his view; the object is not an isolated thing of exquisite tints or admirable shape; it takes its place in the vast system of nature, and derives grandeur beyond estimate from its relations to that system. Nature becomes a living expression — as full as is possible in finite language — of the perfections of the Supreme Architect, with whom to create has ever been to evolve beauty amid displays of wisdom and beneficence. And the devout mind finds deeper meaning in the words Reverence and Humility, and ceaseless promptings to his Gratitude and Love.

We have reason for gratulation that correct views respecting Natural and Physical Science are rapidly becoming general throughout our land. Among its votaries, while

every new fact is heartily welcomed to its place, there is a strong distaste for human fancies as a substitute for divine truths, or for theories without a broad basis of ascertained facts. Moreover, there is, at large, an appreciation of the value of science, not merely for its baser purpose of turning everything into gold, but for its nobler end of opening the earlier revelation. The means also for the prosecution of science are gradually extending, and it is favorably recognized, with hardly an exception, in all the literary institutions of the country, though not generally raised to that honorable place which it may expect in the future.

Happily, too, there is much to encourage extended research in the opportunities now before us for the publication of elaborate original memoirs. Not, indeed, in the small treasury of this Association, which boasts more of the mutual good-will and the ideas it elicits than of its moneyed resources, but in the transactions of different scientific societies or academies and the periodical press, and pre-eminently in the Smithsonian Institution, through the munificence of Smithson, who gave his fortune expressly for this end, — the *increase* and *diffusion* of knowledge among men. It has been recently attempted to strike out the *idea*, if not the *word increase*, and, in equal wisdom, it was thought to *diffuse knowledge* over this extended territory and the world by stationing a collection of books at Washington. Fortunately for knowledge and the country such counsels have not prevailed. The funds for publication and for its other legitimate purposes are, in fact, lamentably small. An annual income of thirty-one thousand dollars, diminished one third by the incidental expenses of the Institution, is a meagre allowance. The complete elaboration and publication yearly of the meteorological results, from the facts now constantly coming in, would alone require half the available publication fund; and, on account of its expense, has not yet been attempted. And what shall be said of other departments, and the costly illustrations which detailed investigations require? It is well the country

has what it has. It would be vastly more for its interests, and for the increase and diffusion of knowledge among men, if the resources for publication were tenfold larger.

In selecting a topic for this occasion, I have not been without perplexity. Before an Association for the Advancement of Science, — science in its wide range, — a discourse on the progress of science in America for the past year would seem legitimate. Yet it is a fact that the original memoirs in most departments, published within that period, would make a very meagre list. Moreover, it is too much to expect of any one to roam over other's territories, lest he ignorantly gather for you noxious weeds. I have, therefore, chosen to confine myself to a single topic, that of Geology; and I propose, instead of simply reviewing recent geological papers, to restrict myself to some of the general conclusions that flow from the researches of American geologists, and the bearing of the facts or conclusions on geological science. I shall touch briefly on the several topics, as it is a subject that would more easily be brought into the compass of six hours than one. In drawing conclusions among conflicting opinions, or on points where no opinion has been expressed, I shall endeavor to treat the subject and the views of others in all fairness, and shall be satisfied if those who differ from me shall acknowledge that I have honestly sought the truth.

In the first place, we should have a clear apprehension of the intent or aim of Geological Science. It has been often said, that Geology is a *history*, the records of which are written in the rocks; and such is its highest department. But is this clearly appreciated? If so, why do we find text-books, even the one highest in authority in the English language, written back end foremost, — like a History of England commencing with the reign of Victoria. In history, the phases of every age are deeply rooted in the preceding, and intimately dependent on the whole past. There is a literal unfolding of events as time moves on, and this is eminently true of Geology.

Geology is not simply the science of rocks, for rocks are but incidents in the earth's history, and may or may not have been the same in distant places. It has its more exalted end, — even the study of the progress of life from its earliest dawn to the appearance of man; and instead of saying that fossils are of use to determine rocks, we should rather say that the rocks are of use for the display of the succession of fossils. Both statements are correct; but the latter is the fundamental truth in the science.

From the progress of life, geological time derives its division into Ages, as has been so beautifully exhibited by Agassiz. The successive phases in the progress of life are the great steps in the earth's history. What if in one country the rocks make a consecutive series without any marked interruption between two of these great ages, while there is a break or convenient starting-point in another; does this alter the actuality of the ages? It is only like a book without chapters in one case, and with arbitrary sections in another. Again, what if the events characteristic of an age — that is, in Geology, the races of plants or animals — appear to some extent in the preceding and following ages, so that they thus blend with one another? It is but an illustration of the principle just stated, that *time is one.* Ages have their progressive development, flowing partly out of earlier time, and casting their lights and shadows into the far future. We distinguish the ages by the culmination of their great characteristics, as we would mark a wave by its crest.

Divisions of time *subordinate* to the great ages will necessarily depend on revolutions in the earth's surface, marked by abrupt transitions either in the organic remains of the region, or in the succession of rocks. Such divisions are not universal. Each continent has its own periods and epochs, and the geologists of New York and other States have wisely recognized this fact, disregarding European *stages* or subdivisions. This is as true a principle for the Cretaceous and Tertiary, as for the Silurian and Devonian. The usurpation of Cromwell

made an epoch in English annals; not in the French or Chinese. We should study most carefully the records, before admitting that any physical event in America was contemporaneous with a similar one in Europe. The unity in geological history is in the progess of life and in the great physical causes of change, not in the succession of rocks.

The geological ages, as laid down by Agassiz, are the following: — I. The AGE OF FISHES, including the Silurian and Devonian; II. The AGE OF REPTILES, embracing from the Carboniferous through the Cretaceous; III. The AGE OF MAMMALS, the Tertiary and Post-tertiary; IV. The AGE OF MAN, or the recent era; — *fishes* being regarded as the highest and characteristic race of the first age; *reptiles* of the second; and *mammals* of the third.

More recent researches abroad, and also the investigations of Mr. Hall in this country, have shown that the supposed Fish remains of the Silurian are probably fragments of Crustacea, if we except those of certain beds near the top of the Silurian; and hence the *Age of Fishes* properly begins with the Devonian. What then is the Silurian? It is pre-eminently the AGE OF MOLLUSKS.

Unlike the other two Invertebrate sub-kingdoms, the *Radiate* and *Articulate*, which also appear in the earliest fossiliferous beds, the *Molluscan* sub-kingdom is brought out in all its grander divisions. There is not simply the type, but the type analyzed or unfolded into its several departments, from the Brachiopods and Bryozoa up to the highest group of all, the Cephalopods. And among these Cephalopods, although they may have been inferior in grade to some of later periods, there were species of gigantic size, the shell reaching a length of ten or twelve feet. The Silurian is therefore most appropriately styled the *Molluscan Age*.

The Palæozoic Trilobites were the lowest among Crustacea, and Crustacea rank low among Articulates. Moreover, Crustacea (and the Articulata in general) did not reach their fullest development until the Human Era.

The Radiata were well represented in the Silurian periods; but, while inferior to the Mollusca as a sub-kingdom, only corals and crinoids, the lower fixed or vegetative species, with rare exceptions, occur in the Silurian or Molluscan Age.

The Articulata and Radiata thus begin early, but with only the lower forms in each, and neither is a leading class in any age.

Viewing the history, then, *zoölogically*, the ages are — the Age of Mollusks, of Fishes, of Reptiles, of Mammals, of Man.

We may now change the point of view to the Vegetable Kingdom. The ages thence indicated would be three: —

I. The *Age of Algæ*, or marine plants, corresponding to the Silurian and Devonian.

II. The *Age of Acrogens*, or flowerless trees, that is, the Lepidodendra, Sigillariæ, and Calamites, — corresponding to the Coal Period and Permian; — a name first proposed by Brongniart, and which may still be retained, as it is far from certain that the Sigillariæ and Calamites are most nearly related to the Coniferæ.

III. The *Age of Angiosperms*, or our common trees, like the Oak, Elm, &c., beginning with the Tertiary.

The interval between the second and third of these ages is occupied mainly by Coniferæ, the Pine tribe, and Cycadeæ, the true Gymnosperms, species of which were abundant in the Coal Period, and have continued common ever since. The Coniferæ, in the simplicity of their flowers and their naked seeds, are next akin to the Acrogens or flowerless trees. Although in the main a flowerless vegetation, for the few supposed remains of flowers observed abroad have been recently referred to undeveloped leaf-buds, it appears probable from the observations of Dr. Newberry, that there were some true flowers over the Ohio prairies, — apparently monocotyledonous, and related to the Lily tribe. But no traces of Palms or monocotyledonous trees have been found in the coal-fields of this country.

Combining the results from the animal and vegetable king-

doms, we should introduce the Age of Acrogens, for the Coal Period and Permian, between the Age of Fishes and Age of Reptiles, — a space in time zoölogically occupied by the overlapping of these two ages.

The order then reads, the Age of Mollusks, of Fishes, of Acrogens or coal plants, of Reptiles, of Mammals, of Man.

The limits of these ages are as distinct as history admits of; their blendings where they join, and the incipient appearance of a type before the age it afterwards characterizes fully opens, are in accordance with principles already explained.

The reality of progress from lower to higher forms is not more strongly marked in these names, properly applied, than in the rocks. If, hereafter, mammals, reptiles, or fishes are found a little lower than now known, it will be changing but a sentence in the history, — not the grand idea which pervades it.

A theory lately broached by one whose recent death has caused universal grief to science, supposes that the Reptilian was an age of diminished life, between the two extremes in time, the Palæozoic and Mammalian Ages. But, in fact, two grand divisions of animals, the Molluscan and Reptilian, at this time reach their climax and begin their decline, and this is the earliest instance of the highest culmination of a grand zoölogical type.

Preceding the Silurian or Molluscan Age, there is the Azoic Age, or *age without animal life*. It was so named by Murchison and De Verneuil, and first recognized in its full importance, and formally announced, in this country, in the Geological Report of Messrs. Foster and Whitney, although previously admitted, in an indefinite way, by most geologists.

It embraces all the lowest rocks, up to the Silurian, for much of the lowest granite cannot be excluded.

The actual absence of animal life in the so-called Azoic Age in this country is rendered highly probable, as Foster and Whitney show, by the fact that many of the rocks are slates and sandstones, like fossiliferous Silurian rocks, and yet have

no fossils; and moreover, the beds on this continent were uplifted and folded, and, to a great extent, crystallized, on a vast scale, before the first Silurian layers were deposited. A grand revolution is here indicated, apparently the closing event of the early physical history of the globe.

As plants may live in water too hot or impure for animals, and moreover, since all nature exemplifies the principle that the earth's surface was occupied with life as soon as fitted, and with the highest forms the conditions of the time allowed, we may reasonably infer that there may have been in Azoic times marine species and plant-infusoria, forms adapted to aid in the earth's physical history; and thus vegetation may have long preceded animal life on the globe.

After these general remarks on the divisions of Geological time, I now propose to take up the characteristic features and succession of events in American Geology.

In the outset we are struck with the comparative simplicity of the North American continent, both in form and structure. In *outline* it is a triangle, the simplest of mathematical figures; in *surface*, it is only a vast plain lying between two mountain ranges, one on either border, the Appalachian from Labrador to Alabama on the east, the Rocky Mountains on the west; and on its *contour* it has water, east, west, north, and south.

Observe too that its border heights are proportioned to the size of the oceans. A *lofty* chain borders the Pacific, a *low* one the narrow Atlantic, while the small Arctic is faced by no proper mountain range.

This principle, that the highest mountains of the continents face the largest oceans, is of wide application, and unlocks many mysteries in Physical Geography. South America lies between the same oceans as North America; it has its eastern low range, its western Andes; and as the oceans widen southward, the continent is there pinched up almost to a narrow mountain ridge. It differs from North America in having a large expanse of ocean, the Atlantic, on the north,

and, correspondingly, it has its northern mountain ridge. The world is full of such illustrations, but I pass them by.

This simplicity of ocean boundary, of surface features, and of outline, accounts for the simplicity of geological structure in North America; or we may make the wider statement, that all these qualities are some way connected with the positions and extent of the oceans, they seeming to point to the principle, that the subsidence of the oceanic basins had determined the continental features; and that both results were involved in the earth's gradual refrigeration, and consequent contraction.

America has thus the simplicity of a single evolved result. Europe, on the contrary, is a world of complexities. It is but one corner of the Oriental continent, which includes Europe, Asia, and Africa, and while the ocean bounds it on the north and west, continental lands inclose it on the south and east. It has ever been full of cross purposes. American strata often stretch from the Atlantic west beyond the Mississippi; and east of the Rocky Mountains, it has but one proper mountain range of later date than the Silurian. Europe is much broken up into basins, and has mountains of all ages: even the Alps and Pyrenees are as recent as the Tertiary.

This wide contrast accounts for the greater completeness or generality of American revolutions, the more abrupt limits of periods, and clearer exhibition of many geological principles.

The geological structure of this country has been made known through the combined researches of a large number of investigators. The names of MACLURE, SILLIMAN, EATON, lead off the roll; HITCHCOCK, the Professors ROGERS, the well-known GEOLOGISTS OF THE NEW YORK SURVEY, OWEN, PERCIVAL, MORTON, CONRAD, TUOMEY, and many others, have made large contributions to the accumulating results. Yet the *system* may be said to have been mainly laid open by four sets of observers, — MORTON for the Cretaceous; CONRAD for the Tertiary; the NEW YORK GEOLOGISTS for the Palæo-

zoic strata; and the Professors Rogers for the Carboniferous beds and the Appalachians.

The succession of Silurian and Devonian rocks in the State of New York is the most complete in the country, and it was well for the science that its rocks were so early studied, and with such exactness of detail. The final display of the Palæontology by Mr. James Hall has given great precision to the facts, and the system has thereby become a standard of comparison for the whole country, and even for the world.

This accomplished, the carboniferous rocks were still to be registered, and the grand problem of New England Geology solved. The Professors Rogers, in the surveys of Pennsylvania and Virginia, followed out the succession of strata from the Devonian through the Coal Period, and thus, in a general way, completed the series. And more than this, they unravelled with consummate skill the contortions among the Appalachians, bringing order out of confusion, and elucidating a principle of mountain-making which is almost universal in its application. They showed that the Silurian, Devonian, and Carboniferous strata, which were originally laid out in horizontal layers, were afterwards pressed on to the northwestward, and folded up till the folds were of mountain height, and that thus the Appalachians had their origin; and also that, by the escaping heat of those times of revolution, extensive strata were altered, or even crystallized.

This key soon opened to us a knowledge of New England Geology, mainly through the labors of Mr. Hall, and also of Professor H. D. Rogers, following up the survey of President Hitchcock; and now these so-called primary rocks, granite, gneiss, schists, and crystalline limestones, once regarded as the oldest crystallizations of a cooling globe, are confidently set down as for the most part no older than the Silurian, Devonian, and Carboniferous of New York and Pennsylvania.

Let us now briefly review the succession of epochs in American geological history.

The Azoic Age ended, as was observed, in a period of ex-

tensive metamorphic action and disturbance, — in other words, in a vast revolution. At its close, some parts of the continent were left as dry land, which appear to have remained so, as a general thing, in after times; for no subsequent strata cover them. Such are a region in Northern New York, others about and beyond Lake Superior, and a large territory across the continent from Labrador westward, as recognized by Messrs. Whitney and Hall, and the geologists of Canada.

The Silurian or Molluscan Age next opens. The lowest rock is a sandstone, one of the most widely spread rocks of the continent, stretching from New England and Canada south and west, and reaching beyond the Mississippi, — how far is not known. And this first leaf in the record of life is like a title-page to the whole volume, long afterwards completed; for the nature of the history is here declared in a few comprehensive enunciations.

1. The rock, from its thin, even layers, and very great extent, shows the wide action of the ocean in distributing and working over the sands of which it was made; and the ocean ever afterwards was the most active agency in rock-making.

2. Moreover, ripple-marks, such as are made on our present sea-shores or in shallow waters, abound in the rock, both through the east and west, and there are other evidences also of moderate depths, and of emerged land; they all announce the wonderful fact, that even then, in that early day, when life first began to light up the globe, the continent had its existence: — not in embryo, but of full-grown extent; and the whole future record is but a working upon the same basis, and essentially within the same limits. It is true that but little of it was above the sea, but equally true that little of it was at great depths in the ocean.

3. Again, in the remains of life which appear in the earliest layers of this primal rock, three of the four great branches of the Animal Kingdom are represented, — Mollusks, Trilobites among Articulates, and Corals and Crinoids among Radi-

ates, — a sufficient representation of life for a title-page. The New York beds of this rock had afforded only a few Mollusks; but the investigations of Owen in Wisconsin have added the other tribes; and this diversity of forms is confirmed by Barrande in his Bohemian researches.

Among the genera, while the most of them were ancient forms that afterwards became extinct, and through succeeding ages thousands of other genera appeared and disappeared, the very earliest and most universal was one that now exists, — the genus *Lingula*, — thus connecting the extremes of time, and declaring most impressively the unity of creation. Mr. T. S. Hunt, of the Canada Geological Survey, recently discovered that the ancient shell had the anomalous chemical constitution of bones, being mainly phosphate of lime; and afterwards he found in a modern Lingula the very same composition, — a further announcement of the harmony between the earliest and latest events in geological history.

This earliest sandstone, — called in New York the Potsdam sandstone, — and the associate Calciferous Sand-rock, mark off the *First Period* of the Molluscan Age, — the Potsdam Period, as it may be called.

Next followed the Trenton Period, — a period of limestones, (the Trenton limestone among them,) equal to the earlier beds in geographical limits, and far more abundant in life, for some beds are literally shells and corals packed down in bulk: yet the species were new to the period, the former life having passed away; and even before the Trenton Period closed, there were one or two epochs of destruction of life followed by new creations. The formation of these limestone beds indicates an increase in the depth of the continental seas, — an instance of the oscillation of level to which the earth's crust was almost unceasingly subject through all geological ages until the present.

After the Trenton Period, another change came over the continent, and clayey rocks or shales were formed in thick deposits in New York, and south, — the Utica slate and Hud-

son River shales, — while limestones were continued in the West. This is the HUDSON PERIOD; and with it, the *Lower Silurian* closed.

The seas were then swept of their life again, and an abrupt transition took place both in species and rocks. A conglomerate covered a large part of New York and the States south, its coarse material evidence of an epoch of violence and catastrophe: and with this deposit the *Upper Silurian* began.

The Upper Silurian had also its three great periods, — the NIAGARA, the ONONDAGA, and the LOWER HELDERBERG, besides many subordinate epochs, — each characterized by its peculiar organic remains, — each evidence of the nearly or quite universal devastation that preceded it, and of the act of omnipotence that reinstated life on the globe, — each, too, bearing evidence of shallow or only moderately deep waters when they were formed; and the Onondaga Period — the period of the New York salt rocks — telling of a half-emerged continent of considerable extent.

Another devastation took place, and then opened, as De Verneuil has shown, the Devonian Age, or *Age of Fishes*. It commenced, like the Upper Silurian, with coarse sandstones, evidence of a time of violence; these were followed by another grit rock, whose few organic remains show that life had already reappeared. Then another change, — a change evidently in depth of water, — and limestones were forming over the continent, from the Hudson far westward: the whole surface became an exuberant coral reef, far exceeding in extent, if not in brilliancy, any modern coral sea; for such was a portion, at least, of the UPPER HELDERBERG Period.

Again there was a general devastation, leaving not a trace of the former life in the wide seas; and where were coral reefs, especially in the more eastern portion of the continental seas, sandstones and shales accumulated for thousands of feet in thickness, with rarely a thin layer of limestone. Thus passed the HAMILTON, CHEMUNG, and CATSKILL Periods, of the Devonian age. The life of these regions, which in some

epochs was exceedingly profuse, was three or four times destroyed and renewed: — not renewed by a re-creation of the same species, but by others; and although mostly like the earlier in genera, yet each having characteristic marks of the period to which it belonged. And while these Devonian Periods were passing, the first land plants appeared, foretellers of the Age of Verdure, next to follow.

Then come vast beds of conglomerate, a natural opening of a new chapter in the record; and here it is convenient to place the beginning of the Carboniferous Age, or the Age of Acrogens. Sandstones and shales succeeded, reaching a thickness, in Pennsylvania and New Jersey, according to Professor Rogers, of thousands of feet; while in the basin of the Ohio and Mississippi, in the course of this era, the Carboniferous limestone was forming from immense crinoidal plantations in the seas.

Another extermination took place of all the beautiful life of the waters, and a conglomerate or sandstone was spread over the encrinital bed: and this introduced the true coal period of the Carboniferous Age; — for it ended in leaving the continent, which had been in long-continued oscillations, quite emerged. Over the regions where encrinites were blooming, stretch out vast prairies or wet meadows of the luxuriant coal vegetation. The old system of oscillations of the surface still continues, and many times the continent sinks to rise again, — in the sinking, extinguishing all continental life, and exposing the surface to new depositions of sandstone, clays, or limestone over the accumulated vegetable remains; in the rise, depopulating the seas by drying them up, and preparing the soil for verdure again, or at times convulsive movements of the crust carry the seas over the land, leaving destruction behind: and thus by repeated alternations the coal period passes, some six thousand feet of rock and coal-beds being formed in Pennsylvania, and fourteen thousand feet in Nova Scotia.

I have passed on in rapid review, in order to draw attention

to the series or succession of changes, instead of details. So brief an outline may lead a mind not familiar with the subject to regard the elapsed time as short; whereas to one who follows out the various alternations and the whole order of events, the idea of *time immeasurable* becomes almost oppressive.

Before continuing the review, I will mention some conclusions which are here suggested.

I. In the first place, through the periods of the Silurian and Devonian, at twelve distinct epochs, at least, the seas over this American continent were swept of all, or nearly all, existing life, and as many times it was repeopled: and this is independent of many partial exterminations and renewals of life that at other times occurred.

If Omnipotent Power had been limited to making *monads* for after development into higher forms, many a time would the whole process have been utterly frustrated by hot water, or by mere changes of level in the earth's crust, and creation would have been at the mercy of dead forces. The surface would have required again and again the sowing of monads, and there would have been a total failure of crops after all; for these exterminations continue to occur through all geological time into the Mammalian Age.

II. Again: I have observed that the continent of North America has never been the deep ocean's bed, but a region of comparatively shallow seas, and at times emerging land; and was marked out in its great outlines even in the earliest Silurian. The same view is urged by De Verneuil, and appears now to be the prevailing opinion among American geologists. The depth at times may have been measured by the thousand feet, but not by miles.

III. During the first half of the lower Silurian era, the whole east and west were alike in being covered with the sea. In the first or Potsdam Period, the continent was just beneath its surface. In the next or Trenton Period, the depth was greater, giving purer waters for abundant marine life. After-

wards, the East and West were in general widely diverse in their formations; limestones, as Mr. Hall and the Professors Rogers have remarked, were in progress over the West, that is, the region, now the great Mississippi Valley, beyond the Appalachians, while sandstones and shales were forming, from Northeastern New York, south and southwest through Virginia. The former, therefore, has been regarded as an area of deeper waters, the latter as, in general, shallow, when not actually emerged. In fact, the region towards the Atlantic border, afterwards raised into the Appalachians, was already, even before the Lower Silurian era closed, the higher part of the land: it lay as a great reef or sand-bank, partly hemming in a vast continental lagoon where corals, encrinites, and mollusks grew in profusion, thus separating more or less perfectly the already existing Atlantic from the interior waters.

IV. The oscillations or changes of level over the continent, through the Upper Silurian and Devonian, had some reference to this border region of the continent: the formations approach or recede from it, and sometimes pass it, according to the limits of the oscillation eastward or westward. Along the course of the border itself there were deep subsidences in slow progress, as is shown by the thickness of the beds. It would require much detail to illustrate these points, and I leave them with this bare mention.

The Hudson River and Champlain valleys appear to have had their incipient origin at the epoch that closed the Lower Silurian; for while the preceding formations cross this region and continue over New England, the rocks of the Niagara and Onondaga Periods (the first two of the Upper Silurian) thin out in New York before reaching the Hudson River. Mr. Logan has recognized the division of America to the northeast into two basins by an anticlinal axis along Lake Champlain, and observes also that the disturbances began as early, at least, as the close of the Lower Silurian, mentioning, too, that there is actually a want of conformity at Gaspé between the beds of the Upper and Lower Silurian, —

another proof of the violence that closed the Lower Silurian era.

But let us pass onward in our geological record.

All the various oscillations that were in slow movement through the Silurian, Devonian, and Carboniferous Ages, and which were increasing their frequency throughout the last, raising and dipping the land in many alternations, were premonitions of the great period of revolution, — so well elucidated, as already observed, by the Professors Rogers, — when the Atlantic border, from Labrador to Alabama, long in preparation, was at last folded up into mountains, and the Silurian, Devonian, and Carboniferous rocks were baked or crystallized. No such event had happened since the revolution closing the Azoic Period. From that time on, all the various beds of succeeding ages up to the top of the Carboniferous had been laid down in horizontal or nearly horizontal layers, over New England as well as in the West, — for the continent from New England westward, we have reason to believe, was then nearly a plain, either above or below the water; there had been no disturbances except some minor uplifts: the deposits, with small exceptions, were a single unbroken record, until this Appalachian revolution.

This epoch, although a time of vast disturbances, is more correctly contemplated as an epoch of the slow measured movement of an agency of inconceivable power, pressing forward from the ocean towards the northwest; for the rocks were folded up without the chaotic destruction that sudden violence would have been likely to produce. Its greatest force and its earliest beginning was to the northeast. I have alluded to the disturbance between the Upper and Lower Silurian beds of Gaspé, to the north: another epoch of disturbance, still more marked, preceded, according to Mr. Logan, the Carboniferous beds in those northeastern regions; and New England, while a witness to the profound character and thoroughness of the Appalachian revolution, attests also to the greater disturbance towards its northern limits. Some

of the Carboniferous strata were laid down here in Rhode Island, as clay and sand and layers of vegetable *débris:* they came forth from the Appalachian fires as you now have them, the beds contorted, the coal layers, a hard siliceous anthracite or even graphite in places, the argillaceous sands and clays, crystallized as talcose schist, or perhaps gneiss or syenite.

These very coal-beds, so involved in the crystalline rocks, are part of the proof that the crystallization of New England took place after the Coal Era. Fossils in Maine and Massachusetts add to the evidence; the quiet required by the continent for the regular succession and undisturbed condition of the rocks of the Silurian, Devonian, and Carboniferous formations, shows that in neither of these ages could such vast results of metamorphic action and upheaval have taken place.

The length of time occupied by this revolution is beyond all estimate. Every vestige of the ancient Carboniferous life of the continent disappeared before it. In Europe, a Permian Period passed, with its varied life; yet America, if we may trust negative evidence, still remained desolate. The Triassic Period next had its profusion of living beings in Europe, and over two thousand feet of rock; America through all, or till its later portions, was still a blank: not till near the beginning of the Jurassic Period do we find any traces of new life, or even of another rock above the Carboniferous.

What better evidence could we have than the history of the oscillations of the surface, from the earliest Silurian to the close of the Carboniferous Age, and the final cresting of the series in this Appalachian revolution, that the great features of the continent had been marked out from the earliest time? Even in the Azoic, the same northeast and southwest trend may be observed in Northern New York and beyond Lake Superior, showing that, although the course of the great Azoic lands was partly east and west, the same system of dynamics that characterized succeeding ages was then to some extent apparent.

The first event in the records after the Appalachian revolution, was the gathering up of the sands and rolled fragments of the crystallized rocks and schists along the Atlantic border into beds; not over the whole surface, but in certain valleys, which lie parallel with the Appalachian chain, and which were evidently a result of the foldings of that revolution. The beds are the red sandstones and shales, which stretch on for one hundred and twenty miles in the Connecticut valley; and similar strata occur in Southeastern New York, in New Jersey, Virginia, and North Carolina. These long valleys are believed to have been estuaries, or else river courses.

The period of these deposits is regarded as the earlier Jurassic by Professor W. B. Rogers. Dr. Hitchcock supposes that a portion of the preceding or Triassic Period may be represented.

Many of the layers show, by their shrinkage cracks, ripple-marks, and footprints, as others have observed, that they were formed in shallow waters, or existed as exposed mud-flats. But they accumulated till they were over a thousand feet thick in Virginia, and in New England two or three thousand, according to the lowest estimate. Hence the land must have been sinking to a depth equal to this thickness, as the accumulation went on, since the layers were formed successively at or near the surface.

Is it not plain, then, that the oscillations, so active in the Appalachian revolution, and actually constituting it, had not altogether ceased their movements, although the times were so quiet that numerous birds and reptiles were tenants of the Connecticut region? Is it not clear that these old valleys, occurring at intervals from Nova Scotia to South Carolina, originally made by foldings of the earth's crust, were still sinking?

And did not the tension below of the bending rocks finally cause ruptures? Even so: and the molten rock of the earth's interior which then escaped, through the crystalline rocks beneath and the overlying sandstone, constitutes the

trap mountains, ridges, and dikes, thickly studding the Connecticut Valley, standing in palisades along the Hudson, and diversifying the features of New Jersey and parts of Virginia and North Carolina. The trap is a singularly constant attendant on the sandstone, and everywhere bears evidence of having been thrown out soon after the deposition of the sandstone, or in connection with the formation of its later beds. Even the small sandstone region of Southbury, Ct., has its trap. Like the Appalachian revolution, this epoch had its greatest disturbances at the north.

Thus ended in fire and violence, and probably in submergence beneath the sea, the quiet of the Connecticut valley, where lived, as we now believe, the first birds of creation; kinds that were nameless, until, some countless ages afterwards, President Hitchcock tracked them out, found evidence that they were no unworthy representatives of the feathered tribe, and gave them and their reptile associates befitting appellations.

Such vast regions of eruptions could not have been without effusions of hot water and steam, and copiõus hot springs. And may not these heated waters and vapors, rising through the crystalline rocks below, have brought up the copper ores, that are now distributed, in some places, through the sandstone? The same cause, too, may have given the prevalent red color to the rock, and produced changes in the adjoining granite.

After the era of these rocks, there is no other American record during the European Jurassic Period.

In the next or Cretaceous Period, the seas once more abound in animal life. The position of the cretaceous beds around the Atlantic border show that the continent then stood above the sea very much as now, except at a lower level. The Mississippi valley, which, from the Silurian, had generally been the region of deeper waters, was even in cretaceous times occupied to a considerable extent by the sea, — the Mexican Gulf then reaching far north, even high up the

Missouri, and covering also a considerable part of Texas and the Rocky Mountain slope.

An age later, the cretaceous species had disappeared, and the Mammalian Age (or the Tertiary, its first Period) begins, with a wholly new Fauna, excepting, according to Professor Tuomey, some half a dozen species, about which however there is much doubt. The continent was now more elevated than in the preceding age, and the salt waters of the Mexican Gulf were withdrawn from the region of Iowa and Wisconsin, so as not to reach beyond the limits of Tennessee.

Two or three times in the course of the Tertiary Period, the life of the seas was exterminated, so that the fossils of the later Tertiary are not identical with any in the earliest beds, — excluding some fish remains, species not confined to the coast waters. The crust of the earth was still oscillating; for the close of the first Tertiary epoch was a time of subsidence; but the oscillation or change of level was slight, and by the end of the Tertiary, the continent on the east stood within a few feet of its present elevation, while the Gulf of Mexico was reduced nearly to its present limits.

I have thus brought this rapid sketch to the close of the Tertiary, having omitted much of great interest, in order to direct attention to the one grand fact, — that the continent from the Potsdam sandstone, or before, to the Upper Tertiary, was one in its progress, — a single consecutive series of events according to a common law. It is seen, that the great system of oscillations, due to force pressing or acting from the southeast, which reached its climax in the rise of the Appalachians, then commenced a decline. We mark these oscillations still producing great results in the Jurassic Period along the whole eastern border from Nova Scotia to the Carolinas. Less effect appears in the Cretaceous Period, and gradually they almost die out as the Tertiary closes, leaving the Mississippi Valley and the eastern shores near their present level.

Thus were the great features of Middle and Eastern North America evolved; nearly all its grand physical events, in-

cluding its devastations and the alternations in its rocks, were consequent upon this system of development.

Moreover, as I have observed, this system was some way connected with the relative positions of the continent and the oceanic basin, — meaning by the latter the profound depressions in which the oceans lie, and not including the shallow-water borders, which are only submerged portions of the Continent.

We need yet more definite knowledge of the Pacific border of North America to complete this subject. It is in accordance with the fact that the highest mountains are there, that volcanoes have been there in action; and also that, in the Tertiary Period, elevations of one to two thousand feet took place; and immediately before the Tertiary a still greater elevation of the Rocky Mountains across from east to west occurred. The system of changes between the Rocky Mountains and the Pacific has been on a grander scale than on the Atlantic border, and also from a different direction, — and this last is an element for whose influence on the general features we cannot yet make full allowance.

Through all this time, central British America appears to have taken little part in the operations; and what changes there were, except, it may be, in the Arctic regions, conformed to the system prevailing farther south, for the rocks of the Jurassic Age, like the Connecticut River sandstone, are found as far north as Prince Edward's Island, in the Gulf of St. Lawrence.

But the Tertiary Period does not close the history of the continent. There is another long Period, the Post-tertiary, — the period of the Drift, of the Mastodon and Elephant, of the lake and river Terraces, of the marine beds on Lake Champlain and the St. Lawrence, — all anterior to the Human Era.

From this time there is a fundamental change in the course of operations. The oscillations are from the north, and no longer from the southeast.

The *drift* is the first great event, as it underlies the other loose material of the surface; and all recognize it as a *northern* phenomenon, connected with northern oscillations.

The upper terrace of the lakes and rivers, and also the marine beds four hundred feet above the level of Lake Champlain, and five hundred above the St. Lawrence, which have been called Laurentian deposits, are marks of a *northern* depression, as no one denies.

The subsequent elevation to the present level again, by stages marked in the lower river terraces, was also *northern*, affecting the region before depressed.

The south felt but slightly these oscillations.

There are thus the following epochs in the Post-tertiary: — the *Drift Epoch;* the *Laurentian Epoch*, an epoch of depression; the *Terrace Epoch*, an epoch of elevation; — *three* in number, unless the Drift and Laurentian Epochs are one and the same.

As this particular point is one of much interest in American Geology, I will briefly review some of the facts connected with the drift.

The drift was one of the most stupendous events in geological history. In some way, by a cause as wide as the continent, — and, I may say, as wide nearly as the world, — stones of all sizes, to immense boulders of one to two thousand tons' weight, were transported, along with gravel and sand, over hills and valleys, deeply scratching the rocks across which they travelled. Although the ocean had full play in the many earlier ages, and an uneasy earth at times must have produced great convulsions, in no rock strata, from the first to the last, do we find imbedded stones or boulders at all comparable in magnitude with the immense blocks that were lifted and borne along for miles in the drift epoch.

Much doubt must remain about the origin of the drift, until the courses of the stones and scratches about mountain ridges and valleys shall have been exactly ascertained. The general course from the North is admitted, but the special facts prov-

ing or disproving a degree of dependence on the configuration of the land have not yet been sufficiently studied.

One theory, the most prevalent, supposes a deep submergence over New England and the North and West, even to a depth of four or five thousand feet, and conceives of icebergs as floating along the blocks of stone, and at bottom scratching the rocks. Another, that of the Professors Rogers, objects to such a submergence, and attributes the result to an incursion of the ocean from the north, in consequence of an earthquake movement beneath the Arctic Seas.

The idea of a submergence is objected to on the ground that the sea has left no proofs of its presence by fossils, or sea-shore terraces or beaches.

Unless the whole continent were submerged, of which there is no evidence whatever, there must have been in the Post-tertiary Period an east-and-west line of sea-shore, say across New Jersey, Pennsylvania, Southern Ohio, and the other States west, or still farther south; and yet no such sea-shore marks now exist to trace its outline, although the ocean must have been a portion of the same that had laid up the Cretaceous and Tertiary beds all along the coasts, and, in fact, already contained the oysters and clams, and many other species of Mollusks which now exist. Can it be, that, contrary to all the ways of the past, such a grand submergence as this view supposes, placing New England four thousand feet under water, could have transpired without a sea-shore record?

Very many have replied in the affirmative; and one able advocate of this view, who sees no difficulty in the total absence of sea-shore terraces or fossils at all levels above the Laurentian beds, finds in the succeeding epoch sea-shore accumulations in all the terraces of our rivers. Why this wonderful contrast? What withheld the waves from acting like waves in the former case, and gave unbounded license in the latter?

This much, then, seems plain, that the evidence, although

negative, is very much like positive proof that the land was not beneath the sea to the extent the explanation of the drift phenomena would require.

There are other objections to this view of submergence. If North America were submerged from the southern boundary-line of the drift far into the Arctic regions, this would have made a much warmer climate for the continent than now; if only half-way, then there is another east-and-west shore line to be traced out, before the fact of the submergence can be admitted. Again, we know how the ice, while a glacier, or along a shore of cliffs, (for all bergs are believed to have once been glaciers,) may receive upon them, or gather up, heavy blocks of stone, even a thousand tons in weight, and bear them off to distant regions, as now happens in the Northern Atlantic. But we have no reason to believe that the massy foot of a berg could pick up such blocks and carry them twenty miles, to drop them again; and hence the short distance of travel would prove that the bergs were made that short distance to the north, and this implies the existence there of glacier valleys and requires a glacier theory.

But without considering other difficulties, I pass to the inquiry, Whether the lands, if not submerged, were at any higher level than now?

There is evidence of striking character, that the regions or coasts over the higher latitudes, in both the northern and southern hemispheres, were once much elevated above their present condition. The *fiords*, or deep coast channels, scores of miles long, that cut up the coast of Norway and Britain, of Maine, Nova Scotia, and Greenland, of Western America from Puget's Sound north, of Southern South America from Chiloe south, of Van Diemen's Land and other southern islands, are all valleys that could not have been scooped out when filled with the ocean's water as now; that could have been formed only when the land in those high latitudes, north and south, was elevated till their profound depths were nearly dry. Whether this elevation was in the period of the Post-

tertiary has not been precisely ascertained. But as they are proof of a north-and-south system of oscillations, the same that was in action in the drift epoch, and as the cold that such a change would occasion is not very distinctly apparent in the Tertiary period, and much less in the earlier, we have reason for referring the greater part of the elevation to that drift era, and for believing that the excavation of these fiord valleys was then in progress. Both fiords and drift are alike high-latitude phenomena on all the continents, north and south. The change of climate between the Cretaceous and Tertiary, and the absence of Tertiary beds north of Cape Cod, may have been connected with an incipient stage in this high-latitude movement.

However this be, there is other evidence, in the cold of the drift period, of some extraordinary cause of cold. The drift in Europe and Britain is generally attributed to glaciers and icebergs during a period of greater cold than now; and the fact of this greater cold is so generally admitted, that it is common to speak of it as the glacial period. Professor Agassiz, moreover, has urged for this continent the glacial theory.

In a memoir of great research, by Mr. Hopkins, of Cambridge, England, the able author maintains that this glacial cold might have been produced over Europe, partly at least, by a diversion of the Gulf Stream from its present position. He seems in his paper to attribute too much effect to the Gulf Stream, and too little to the prevailing currents of the atmosphere; but, setting this aside, it is unfortunate for the hypothesis, that there is no reason to suppose that America was not then as much in the way of such a diversion as now. The small changes of level which the Tertiary and Post-tertiary beds of the Gulf have undergone, prove that the gate of Darien was early closed, and has since continued closed. America, as far as ascertained facts go, has not been submerged to receive the Stream over its surface. If it had been, it would have given other limits to her own drift phenomena; for it is

an important fact that these limits in America and Europe show the very same difference in the climates or in the isothermals as that which now exists.

On the question of the drift, we therefore seem to be forced to conclude, whatever be the difficulties we may encounter from the conclusion, that the continent was not submerged, and therefore icebergs could not have been the main drift agents: the period was a cold or glacial epoch, and the increase of cold was probably produced by an increase in the extent and elevation of northern lands. Further than this, in the explanation of the drift, known facts hardly warrant our going.

If, then, the drift epoch was a period of elevation, it must have been followed by a deep submergence to bring about the depression of the continent, already alluded to, when the ocean stood four hundred feet in Lake Champlain, and a whale (for his bones have been found by the Rev. Z. Thompson of Burlington) was actually stranded on its shores; and when the upper terrace of the rivers was the lower river-flat of the valleys. This submergence, judging from the elevated sea-beaches and terraces, was five hundred feet on the St. Lawrence and Lake Champlain; eighty feet at Augusta, Maine; fifty feet at Lubec; thirty at Sancoti Head, Nantucket; over one hundred at Brooklyn, N. Y.; and two hundred to two hundred and fifty in Central New England, just north of Massachusetts; while south, in South Carolina, it was but eight or ten feet.

But whence the waters to flood valleys so wide, and produce the great alluvial plain constituting the upper terrace, so immensely beyond the capability of the present streams? Perhaps, as has been suggested for the other continent, and by Agassiz for this, from the melting snows of the declining glacier epoch. The frequent absence of fine stratification, so common in the material of this upper terrace, has often been attributed to a glacier origin.

According to this view, the events of the Post-tertiary Pe-

riod in this country make a single consecutive series, dependent mainly on polar or high-latitude oscillations: — an elevation for the *first* or *Glacial Epoch;* a depression for the *second* or *Laurentian Epoch;* a moderate elevation again, to the present height, for the *third* or *Terrace Epoch.*

The same system may, I believe, be detected in Europe; but, like all the geology of that continent, it is complicated by many conflicting results and local exceptions; while North America, as I have said, is like a single unfolding flower in its system of evolutions.

There is the grandeur of nature in the simplicity to which we thus reduce the historical progress of this continent. The prolonged series of oscillations, acting by pressure from the southeast beneath the Atlantic, reach on through immeasurable ages, producing the many changes of level through the Silurian and Devonian, afterwards with greater frequency in the Carboniferous, and then, rising with quickened energy and power, folding the rocks and throwing up the long range of the Appalachians, with vast effusions of heat through the racked and tortured crust, next go on declining as the Jurassic and Cretaceous Periods pass, and finally fade out in the Tertiary. The northern oscillations, perhaps before in progress, then begin to exhibit their effects over the high temperate latitudes, and continue to the Human Era. The sinking of Greenland, now going on, may be another turn in the movement; and it is a significant fact, that, while we have both there and in Sweden northern changes of level in progress, such great secular movements have nowhere been detected on the tropical parts of the continents.

In deducing these conclusions, I have only stated in order the facts as developed by our geologists. Were there time for a more minute survey of details, the results would stand forth in bolder characters.

The sublimity of these continental movements is greatly enhanced when we extend our vision beyond this continent to other parts of the world. It can be no fortunate coincidence

that has produced the parallelism between the Appalachian system and the grand feature lines of Britain, Norway, and Brazil, or that has covered the north and south alike with drift and fiords. But I will not wander, although the field of study is a tempting one.

In thus tracing out the fact, that there has been a plan or system of development in the history of this planet, do we separate the Infinite Creator from his works? Far from it: no more than in tracing the history of a planet. We but study the method in which Boundless Wisdom has chosen to act in creation. For we cannot conceive that to act without plan or order is either a mark of divinity or wisdom. Assuredly it is far from the method of the God of the universe, who has filled all nature with harmonies; and who has exhibited his will and exalted purpose as much in the formation of a continent, to all its details, as in the ordered evolution of a human being. And if man, from studying physical nature, begins to see only a Deity of physical attributes, of mere power and mathematics, he has but to look within at the combination of the affections with intellect, and observe the latter reaching its highest exaltation when the former are supreme, to discover proofs that the highest glory of the Creator consists in the infinitude of his love.

My plan, laid out in view of the limited time of a single address, has led me to pass in silence many points that seem to demand attention or criticism; and also to leave unnoticed the labors of many successful investigators.

There are some subjects, however, which bear on general Geology, that should pass in brief review.

I. The rock-formations in America may in general be shown to be synchronous approximately with beds in the European series. But it is more difficult to prove that catastrophes were synchronous, that is, revolutions limiting the ages or periods.

The revolution closing the Azoic Age, the *first* we distinctly

observe in America, was probably nearly universal over the globe.

An epoch of some disturbance between the Lower and Upper Silurian is recognized on both continents. Yet it was less complete in the destruction of life on Europe than here, more species there surviving the catastrophe, and in this country there was but little displacement of the rocks.

The Silurian and the Devonian Ages each closed in America with no greater revolutions than those minor movements which divided the subordinate periods in those ages; Mr. Hall observes that they blend with one another, and the latter also with the Carboniferous, and that there is no proof of contemporaneous catastrophes giving them like limits here and in Europe.

But after the Carboniferous came the Appalachian revolution, one of the most general periods of catastrophe and metamorphism in the earth's history. Yet in Europe the disturbances were far less general than with us, and occurred along at the beginning and end of the Permian Period.

From this epoch to the close of the Cretaceous, there were no contemporaneous revolutions, as far as we can discover. But the Cretaceous Period terminates in an epoch of catastrophe which was the most universal on record, all foreign Cretaceous species having been exterminated, and all American, with a few doubtful exceptions. This third general revolution was the prelude to the Mammalian Age. But there is no time to do this subject justice, and I pass on, — merely adding, on account of its interest to those who would understand the first chapter of Genesis, that there is no evidence whatever in Geology, that the earth, after its completion, passed through a chaos and a six days' creation at the epoch immediately preceding man, as Buckland, in the younger days of the science, suggested, on *Biblical*, not on geological, ground. No one pretends that there is a fact or hint in Geology to sustain such an idea: moreover, the science is utterly opposed to it.

II. The question of the existence of a distinct *Cambrian system* is decided adversely by the American records. The Mollusca in all their grand divisions appear in the Lower as well as Upper Silurian, and the whole is equally and alike the Molluscan or Silurian Age. The term Cambrian, therefore, if used for fossiliferous strata, must be made subordinate to Silurian.

The *Taconic system* of Emmons has been supposed by its author to have a place inferior to the Cambrian of Sedgwick, or else on a level with it. But the investigations of Hall, Mather, and Rogers, and more lately of Logan and Hunt, have shown that the Taconic slates belong with the upper part of the Lower Silurian, being, in fact, the Hudson River shales, far from the bottom of the scale.

III. The American rocks throw much light on the origin of coal. Professor Henry D. Rogers, in an able paper on the American Coal-fields, has well shown that the condition of a delta or estuary for the growth of the coal-plants, admitted even now by some eminent geologists, is out of the question, unless the whole continent may be so called; for a large part of its surface was covered with the vegetation. Deltas exist where there are large rivers; and such rivers accumulate and flow where there are mountains. How, then, could there have been rivers, or true deltas of much size, in the Coal Period, before the Rocky Mountains or Appalachians were raised? It takes the Andes to make an Amazon. This remark has a wider application than simply to the Coal Era.

IV. In this connection, I add a word on the idea that the rocks of our continent have been supplied with sands and gravel from a continent now sunk in the ocean. No facts prove that such a continent has ever existed, and the whole system of progress, as I have explained, is opposed to it. Moreover, gravel and sands are never drifted away from seashores, except by the very largest of rivers, like the Amazon; and with these, only part of the lightest or finest detritus is carried far away; for much the larger part is returned to the

coast through tidal action, which has a propelling movement shoreward, where there are soundings. The existence of an Amazon on any such Atlantic continent in Silurian, Devonian, or Carboniferous times, is too wild an hypothesis for a moment's indulgence.

V. The bearing of the facts in American Palæontology on the science, might well occupy another full discourse. I will close with brief allusions to some points of general interest.

1. The change in the Fauna of the globe as the Age of Man approaches, is one of the most interesting facts in the earth's history. It was a change not in the types of the races, (for each continent retains its characteristics,) but a remarkable dwindling in the size of species. In North America the Buffalo became the successor to the huge Mastodon, Elephant, and Bootherium; the small Beaver to the great Castoroides; and the existing Carnivora are all comparatively small.

Parallel with this fact, we find that in South America, as Dr. Lund observes, where, in the last age before Man, there were the giant Megatherium and Glyptodon, and other related Edentates, there are now the small Sloths, Armadillos, and Ant-eaters.

So, also, on the Oriental continent, the gigantic Lion, Tiger, Hyena, and Elephant, and other monster quadrupeds, have now their very inferior representatives.

In New Holland, too, the land of Marsupials, there are Marsupials still, but of less magnitude.

2. This American continent has contributed to science a knowledge of some of the earliest traces of Reptiles, — the species of the Pennsylvania coal formation, described by Mr. King and Mr. Lea, and others from the Nova Scotia coal-fields, discovered by Messrs. Dawson and Lyell.

It has afforded the earliest traces of birds thus far deciphered in geological history, — the colossal and smaller waders, whose tracks cover the clayey layers and sandstone of the Jurassic rocks in the Connecticut valley. The earliest

Cetacea yet known are from the American Cretaceous beds, as described by Dr. Leidy. And among the large Mammals which had possession of the renewed world after the Cretaceous life had been swept away, the largest, as far as has been ascertained, lived on this continent. The Palæotheria of the Paris Basin, described by Cuvier, were but half the size of those of Nebraska.

But here our boasting ceases, for, as Agassiz has shown, the present Fauna of America is more analogous to the later Tertiary of Europe than to the existing species of that continent.

In the Palæozoic Ages, to the close of the Coal Period, the American continent was as brilliant and profuse in its life as any other part of the world. It was a period, indeed, when the globe was in an important sense a unit, not individualized in its climates or its distribution of life, and only partially in its seas. But from this time the contrast is most striking.

The whole number of known American species of animals of the Permian, Triassic, Jurassic, Cretaceous, and Tertiary Periods is about two thousand; while in Britain and Europe, a territory even smaller, there were over twenty thousand species. In the Permian we have *none*, while Europe has over two hundred species. In the Triassic, *none;* Europe, one thousand species. In the Jurassic, sixty; Europe, over four thousand. In the Cretaceous, three hundred and fifty to four hundred; Europe, five to six thousand. In the Tertiary, hardly fifteen hundred; Europe, about eight thousand.

America, since Palæozoic times, has therefore been eminent for the poverty of its Fauna.

Again: the Mammalian Age in America, although commencing with huge Pachyderms, shows little progress afterward. The larger quadrupeds continue to be mainly herbivorous, and the Carnivora, the higher group, are few and of comparatively small size. *The Herbivora are still the typical species.* While in Europe and Asia, at the same time, — that is, in the Post-tertiary, — the Carnivora are of great size

and ferocity, far exceeding the largest of modern Lions and Tigers. The single species of Lion described, from a bone from near Natchez, by Dr. Leidy, hardly lessens the contrast.

South America, as has been remarked by Agassiz and others, sustains this inferior position of America. The huge Sloths, Megatheria, and other Edentata of the South, are even lower in grade than the ordinary Herbivora, and place that Southern continent at an inferior level in the scale. Although there were Carnivora, they were much smaller than the European. *The Edentates are*, in fact, *its typical species.*

The supremacy of the great Oriental continent is, therefore, most signally apparent.

The contrast is still greater with Australia and New Zealand, whose past and present Fauna and Flora have been well said by Agassiz and Owen to represent the Jurassic Period, — the present era affording Trigonias, Terebratulæ, Cestraciont Fishes, and the Araucarian Coniferæ, all Jurassic types, besides Kangaroos and Moas. Among Mammals, *the Marsupials*, the lowest of all in the class, *are its typical species.*

Ever since Palæozoic times, therefore, the Oriental Continent, — that is, Europe, Asia, and Africa combined, — has taken the lead in animal life. Through the Reptilian Age, Europe and Asia had species by thousands, while America was almost untenanted. In the later Mammalian Age, North America was yet in the shade, both in its Mammals and lower tribes; South America in still darker shadows; and Australia even deeper still. The earth's antipodes were like light and darkness in their zoölogical contrasts. And was there not in all this a prophetic indication, which had long been growing more and more distinct, that the Eastern Continent would be man's chosen birthplace? that the long series of living beings, which had been in slow progression through incalculable ages, would there at last attain its highest exaltation? that the stupendous system of nature would there be opened to its fullest expansion?

Another of our number has shown in eloquent language how the diversified features and productions of the Old World conspired to adapt it for the childhood and development of the race; and that, when beyond his pupilage, having accomplished his rescue from himself and the tyranny of forces around him, and broken the elements into his service, he needed to emerge from the trammels of the school-house in order to enjoy his fullest freedom of thought and action, and social union. Professor Guyot observes further, that America, ever free, was the appointed land for this freedom and union, — of which its open plains, and oneness of structure, were a fit emblem; and that, although long without signs of progress or hope in its future, this land is to be the centre of hope and light to the world.

In view of all these arrangements, man may well feel exalted. He is the last of the grand series. At his approach, the fierce tribes of the earth drew back, and the race dwindled to one fourth its bulk and ferocity, — the huge Mastodons, Lions, and Hyenas yielding place to other species, better fit to be his attendants, and more in harmony with the new creation.

Partaking of the Divine image, all nature pays him tribute; the universe is his field of study; an eternity his future. Surely it is a high eminence on which he stands.

But yet he is only *one* of the series; one individuality in the vast system. How vain the philosophy which makes the creature the God of nature, or nature its own author! Infinitely beyond man, infinitely beyond all created things, is that Being with whom this system, and the combined systems of immensity, were as one purpose of His will.

Science and Scientific Schools.

AN ADDRESS

BEFORE THE

Alumni of Yale College,

AT THE

COMMENCEMENT ANNIVERSARY, AUGUST, 1856.

By JAMES D. DANA,

SILLIMAN PROFESSOR OF NATURAL HISTORY.

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ADDRESS.

GENTLEMEN OF THE ALUMNI:—

THESE annual pilgrimages over the breadth of the land to the groves of our Alma Mater have deep meaning. No duties of penance, nor hopes of ghostly reward, turn hither your steps. Thoughts of the past possess the soul, rather than care for the future: the familiar faces, the old red buildings, the sheltering trees, and the scenes of mirth, of friendship, or of serious effort, here enacted. Still more stirring is the consciousness with each of us, that amid these groves the mind first rose into manhood, and collected strength for the conflicts of life:—the mind's birth-place,—should not the spot be honored?

Besides these reflections, there is the pride, the just pride, that the nation has within these halls one of its best and most abundant sources of wisdom and virtue;—wisdom that takes hold on heavenly things while striking deep into the things of earth; virtue, that has its sure foundation in universal right and universal freedom.

It is natural on meeting friends, long absent, to seek out the marks of progress, to recount together the joys and trials along the way of life,—the new fields the affections have explored, the new conquests in the career of study or duty, or, perchance, the ineffectual labors and blighted hopes that have demanded still higher conquests. It is natural to ask, whether this or that one has fulfilled the promises of youth; whether he has become wiser with his years, and has expanded in spirit as well as intellect with every new movement of mankind; or, whether the dead languages still lie dead in his soul, himself a thing of the past rather than of the living world. With the varied responses to these and other thoughts, we find some occasion for sadness; much for delight and

gratulation; and, however it be, there is always happiness and invigorating influence from interchanged words and sympathies.

But with many, the inquiries will not stop here. How is it, they add, with our Alma Mater? Does the honored institution show signs of growth in these growing times? or is she linked with the past rather than the future, resisting progress as if it led only toward evil? All life in nature involves change; and there is no hope for humanity except in the same universal principle: but, with perverted view, is change here looked upon as only a step toward destruction?

Sounds have gone forth from these groves, which have told that Yale is awake to all that stirs the world around, declaring that she recognizes in man, yea, in all men, the divine image, and seeks to promote the full expression of that image as the highest exaltation of humanity.

Again, in her literary course, there is progress, as regards the range of studies, the character of examinations, the style of thought, and grade of scholarship.

There is another point of interest connected with the world's progress. The researches of the past one hundred years have opened new fields of thought, new revelations of profound truths direct from God's works, and the world, through the energies thus derived, is pressing onward with accelerating speed. Through the darkness, black as night, that seemed to be a bound to past time but 6,000 years off, geology has opened a vista in which she has traced the Divine Word, in glorious thoughts, all along the Ages. How does the College treat these new notions, and science generally? as modern inventions of Satan? Does she turn her back, and cry "*Procul?*" Does she adopt the half-stereotyped phrase, "The infidelity of modern science," and shed bitter tears because she can not help it? Does she regard the Arts as only so many ministers to luxury and debasement?

There still stands among us one whose eloquent words have for fifty years made the truth resound through these consecrated halls, and whose far-reaching tones have been reëchoed from every portion of the land. And thus Yale College has ever been in the van, never afraid of the progress of truth.

Yet there are many who still look with distrustful eyes on science: (under this term science you will understand me, here and elsewhere, as referring to the science of nature.) They seem to see a monster swelling up before them which they can not define,

and hope may yet fade away as a dissolving mist. They deprecate its influence upon our literary institutions, and the great interests of mankind. The word *nature*, though another expression for God's works, appears to them to smack of Atheism, and all education that touches on the useful, to be tainted with the mammon of unrighteousness. They overlook the fact that almost all works on science in our language, endeavor to uphold the sacred Word, those opposing it being exceedingly few; and that infidelity proceeds not from science, but from that one fatal and prolific source, man's depravity.

Notwithstanding all the protestations that may come from such unbelievers in God's revelations through nature and his plan for human progress, Yale College is ready to encourage science on a scale commensurate with its importance. For some years, the scheme has been recognized in her catalogue, under the title of "The Department of Philosophy and the Arts;" and now it is proposed to realize this scheme, at least in some of its branches. She would not, however, commit the folly of sacrificing herself in deference to philosophy and the arts. Yale will stand as she is, abating not her terms of admission, nor her grade of scholarship, and aiming still to give that thorough classical training, and that broad foundation of principles in the departments of nature, mind, and moral truth, which tend to the complete cultivation of the man. The system she has hitherto followed, though admitting of some improvement, affords in fact the true basis for the student that would ascend the highest paths, whether of literature or science. But she also recognizes that God has purposes of love in opening to man these other avenues of knowledge, and she would offer a place along side of the Academic Department for "Philosophy and the Arts," in their fullest display, where mutual benefits may be derived, and the ripening man find development, whatever his tastes or pursuits.

My object at this time will be mainly to give some account of the university feature in education which it is proposed to connect with the existing college system. But the claims of science are not so generally admitted or understood as to need no advocate; and I ask your attention first to some thoughts on this subject.

When man, at the word of his Maker, stood up to receive his birthright, God pronounced a benediction, and gave him this

commission: "REPLENISH THE EARTH: SUBDUE IT: AND HAVE DOMINION OVER EVERY LIVING THING."

"SUBDUE AND HAVE DOMINION." These were the first recorded words that fell on the human ear; and Heaven's blessing was in them.

Man has long obeyed the mandate in bridling the brute races. But there is a deeper meaning which he has been slow to discover. In utterances, not to be mistaken, they declare to him:—"All the powers of nature, both animate and inanimate, are your heritage. The air, the waters, the earth, the light and the fierce lightning, as well as the productions of sea and land,—all are at your bid. Subdue; and they shall be your obedient aid, ministering to your necessities, your joys, and your highest progress." Even as the Being above us holds the universe in his hand, so man was to show forth the divine nature within him, by bringing under his ken and power, the world in which he was placed, and wielding its forces at his pleasure.

Such a Divine command was a lofty exhibition of the majesty of man. The earth, in its progressive preparation for him, had been receiving one perfection and adornment after another. The stars and earth had been bound together in system, and messages of light passed in mutual recognition of their one Author. The foundations of the earth had been laid in enactments inscribed on every crystal and grain of sand or drop of water. The kingdoms of life had appeared as still nobler expressions of his wisdom. And God, from the height of his glory, had pronounced all his work GOOD. Thus the earth had been the place of Divine regard and favor: the Infinite Author had written it over with declarations of himself, and filled it with messages of his love.

But this volume of eternal wisdom remained yet a sealed book. What an unspeakable exaltation of Man, that to him were given the keys! the power to open, and read, and apprehend, although its words were in the hand-writing of the Infinite Author! to appreciate beauty which to Him was beauty! to decipher and understand the profound system of the universe! to venture on almost boundless excursions through space, and as profound searchings into the past! to appropriate the treasures of life, and turn the currents of nature's forces into his own channels! to rise from the dust of earth to the throne of power, and say to nature, "Go:"—and it goeth! Surely there was a declaration of man's dignity we can not yet apprehend in those words, "SUBDUE IT."

But what is this subduing of the earth? How is nature brought under subjection? Man's highest glory consists in obedience to the Eternal Will; and in this case, is he actually taking the reins into his own hands? Far from it. He is but yielding submission. He is learning that will, and placing himself, as Lord Bacon has said, in direct subserviency to divine laws. When he sets his sails, and drives over the waves before the blast, feeling the pride of power in that the gale has been broken into a willing steed, he still looks up reverently, and acknowledges that God in nature has been his teacher, and is his strength. When he strikes the rock, and out flows the brilliant metal, he admits that it is in obedience to a higher will than his own, and a reward of careful searching for truth, in complete subjection to that will. When he yokes together a plate of copper and zinc, and urges them to action by a cup of acid—and then despatches burdens of thought on errands of thousands of miles, man may indeed claim that he has nature at his bid, subdued, a willing messenger; and yet it is so, because man himself acts in perfect obedience to law. He may well feel exalted: but his exaltation proceeds from the fact that he has drawn from a higher source of strength than himself, and a mind not morally perverted, will give the glory where it is due.

These are the rewards of an humble and teachable spirit, kneeling at the shrine of nature: and if there is indeed that forgetfulness of self, and unalloyed love of truth which alone can ensure the highest success in research, this shrine will be viewed as only the portal to a holier temple, where God reigns in his purity and love.

The command, "subdue, and have dominion," is, then, both a mark of man's power, and of God's power. It requires man to study his Maker's works, that he may adapt himself to his laws, and use them to his advantage;—to become wise, that he may be strong;—to elevate and ennoble mind, that matter may take its true place of subjection. It involves not merely a study of nature in the ordinary sense of those words, but also a study of man himself, and the utmost exaltation of the moral and mental qualities; for man is a part of nature; and moreover, to understand the teachings of Infinite Wisdom, the largest expansion of intellect, and loftiest elevation of soul are requisite.

Leaving out of view the moral aspect of the question, let us look for a moment at the history of man's obedience to this injunction.

Solomon says, that in his day, "there was nothing new under the sun." What is, is what has been, and what shall be. The

sentiment was not prompted by any modern scientific spirit,—impatience of so little progress; for it was immediately connected with sighings for the good *old* times. Much the same spirit is often shown in these days, and elaborate addresses are sometimes written to prove that after all our boasted progress, Egypt and Greece were the actual sources of existing knowledge. They point to the massy stones of the pyramids; the sublime temples and palaces of the old empires; the occasional utensils of half-transparent glass, and implements of bronze or iron found among their buried ruins; the fine fabrics and costly Tyrian dye;—they descant upon the wonderful perfection attained in the fine arts, in poetry and rhetoric, and the profound thought of the ancient philosophers:—and then are almost ready to echo, "There is nothing new under the sun." What is, is what has been. *Those good old times!*

But what had those old philosophers, or the whole ancient world done toward bringing nature under subjection, in obedience to the command, "subdue it?"

They had, it is true, built magnificent temples. But the taste of the architect, and that of the statuary or poet, is simply an emanation from the divine breath within man, and is cultivated by contemplation, and only surface contact with nature.

They piled up Cyclopean rocks into walls and pyramids. But the use of the lever and pulley comes also from the workings of mind, and but shallow views of the world. And adding man to man till thousands work together as in one harness, has been a common feat of despots from the time of the Pharaohs onward.

They educed profound systems of philosophy, showing a depth of thought since unsurpassed. But these again were the results of cogitating mind, acting in its own might,—glancing, it may be, at the landscape and the stars in admiration, but centering on man and mind; and often proving to be as erroneous as profound.

They cultivated the intellect, and made progress in political knowledge. But in their attempts to control nature, they brought to bear little beyond *mere physical force.*

Although ancient wisdom treats of air, earth, fire, and water, not one of these so-called elements was, in any proper sense, brought under subjection.

The *Air:*—Was it subdued, when the old Roman still preferred his banks of oars, and on the land, the wind was trained only to turn a windmill, carry off chaff, or work in a bellows?

Was the *Earth* subdued, when instead of being forced to pour

out in streams its wealth of various ores, but half a dozen metals were known? and instead of being explored and found to be marshalled for man's command, under sixty or more elements, each with its laws of combination and all bound to serve the arts, the wisest minds saw only a mess of earth, something to tread upon, and grow grain and grass?

Was *Fire* subdued, when almost its only uses were to warm, and cook, and to bake clay, and few of its other powers were known, besides those of destruction? or *Light*, when not even its component colors were recognized, and it served simply as a means of sight, in which man shared its use with brutes?

Was *Water* subdued, when it was left to run wild along the water-courses, and its ocean-waves were a terror to all the sailors of the age? when steam was only the ephemeral vapor of a boiling kettle, yet unknown in its might, and unharnessed? when the clouds sent their shafts where they willed? when the constituents of water,—the life-element *oxygen*, and the inflammable *hydrogen*, had not yet yielded themselves to man as his vassals?

Hardly the initial step had been taken, through the thousands of years of the earth's existence, to acquire that control of nature which mind should have, and God had ordered. The sciences of observation and experiment had not emerged from the mists of empiricism and superstition. There were few ascertained principles beyond those that flow from mathematical law, or from cogitations of mind after surface surveys of the world.

No wonder that nature unsubdued should have proved herself a tyrant. She *is* powerful. Vast might is embodied in her forces, that may well strike terror into the uninstructed: and man has shown his greatness in that he has at last dared to claim obedience. The air, earth, water, fire, had become filled with fancied fiends, which any priest or priestess could evoke; and even the harmless moon, or two approaching or receding planets, or the accidental flight of a thoughtless bird, caused fearful forebodings; and a long-tailed comet made the whole world to shake with terror.

Christianity, although radiant with hope, could not wholly break the spell. The Christian's trust, Heaven's best gift to man, makes the soul calm and strong mid dangers, real or unreal; yet it leaves the sources of terror in nature untouched, to be assailed by that power which comes from knowledge.

Man thus suffered for his disobedience. He was the slave,—nature, the feared master, to many even the evil demon himself.

Is this now true of nature? We know that to a large extent, nature is yet unsearched and unsubdued. Still, vast progress has been made toward gaining control of her ten thousand agencies.

In gathering this knowledge, we have not sought for it among the faded monuments and rolls of the *ancients*, as we call the inhabitants of the earth's childhood; but have looked to records of vaster antiquity—the writings of the infinite God in creation, which are now as fresh with beauty and wisdom as when His finger first mapped out the heavens, or traced the flowers and crystals of the earth. This is the fountain whence we have drawn: and what is the result?

How is it with *water* in these last times? Instead of wasting its powers in gambols down valleys, or in sluggish quiet about "sleepy hollows," it is trained to toil. With as much glee as it ever displayed running and leaping in its free channel, a single stream now turns over a million of spindles in this New England.

Changed to steam, there is terror in its strength even now. Yet the laws of steam, of its production, condensation, and elasticity, have been so carefully studied, and also the strength and other qualities of the metal used to confine it, as well as the nature and effects of fuel, that if we are careful not to defy established principles, steam is our most willing worker,—turning saw-mills, printing-presses, cotton-gins,—speeding over our roads with indefinite trains of carriages and freight,—bearing away floating mansions, against wind and tide, across the oceans,—cooking, heating, searching out dyes from coarse logwood, and the like,—and applying itself to useful purposes, one way or another, in almost all the arts. Again, if we will it, and follow nature's laws, water gives up its oxygen and hydrogen, and thus the chemist secures the means of burning even the diamond; the aëronaut makes wings for his adventurous flight, and the light-house derives the famous Drummond light for its work of mercy. And when he chooses, man may unite the oxygen and hydrogen again, and re-form the original water.

Light is no longer a mere colorless medium of sight. We may evoke from it any color we please, either for use or pleasure. We may also take its chemical rays from the rest, or its light rays, or its heat rays, and employ them separately or together; for we have found out where its strength lies in these particulars, so that, at will, light may pass from our manipulations, shorn of its heating power, or of its power of promoting growth or chemical change. Aye, the subtle agent will now use its pencil in taking sketches

from nature, or portraits, if we desire it:—and the work is well done.

The ancient wise men, discoursing on the power which holds matter together, sometimes attributed to the particles convenient hooks for clinging to one another. Little was it dreamed that the force of combination in matter,—now called attraction,—included the lightning among its effects, and would be made to run errands, and do hard work for man. Electricity, galvanism, magnetism, are modern names for some of the different moods under which this agent appears; and none of nature's powers now do better service. It is kept on constant run with messages over the continents, scaling mountains, or traversing seas, with equal facility. It does our gilding and silver-plating. Give it an engraved plate as a copy, and it will make a hundred such in a short time. If taken into employ, it will, in case of fire, set all the bells of a city ringing at once; or it will strike a common beat for all the clocks of a country; or be the astronomer's best and surest aid in observing phases in the heavens, or measuring longitude on the earth. All this and more it accomplishes for us, or can if we wish, besides opening to our inquiring eyes the profound philosophy which God has inscribed in his works.

Nature is no longer full of gloom and terror. Her fancied fiends have turned out friends. Although God still holds supreme control, and often makes man remember whence his strength, yet every agent, however mighty in itself, is becoming a gentle and ready assistant, both in our work and play,—in the material progress of nations, as well as their moral and intellectual advancement. Art is thence receiving daily contributions, and already realizes that no knowledge for service, compares with that which comes direct from nature.

It is apparent also, that only the most profound and scrutinizing research, with an earnest and docile spirit, can discover the unseen wealth of nature; for the great truths which have proved so fertile in results, have been sought out by those only who have given themselves, with all their might, to the deep study of God's laws in his works.

Thus it is that fact has been added to fact, until facts have become principles, and principles have expanded until they finally blossomed and spread their fragrance and fruit over the land, while the many receiving the blessing were ignorant whence it came.

A farther reference to the history of science will exhibit more

clearly the dependence of the arts on scientific progress; and I must ask your indulgence, if I refer to familiar facts for the sake of illustration.

Some knowledge of electricity, that is, the power evolved on rubbing glass, amber, resin, or sealing-wax, and other substances, was afloat in the ancient world. But until near fifty-six hundred years had passed, there was not an established principle even in prospect. A little more than a century since, the power was at last collected in quantities and imprisoned by means of the Leyden jar. Its shocks and sparks and other feats were among the wonders of science; but art had yet reaped nothing.

At this time, Franklin commenced experimenting on electricity; for the bruit of the Leyden jar had crossed the waters. He at once thought he saw miniature lightning in the sparks; and soon after, by means of his kite, as you well know, proved his induction right. After thus tapping the clouds for his experiments, he asked, Why not disarm the clouds, by planting perpetual conductors about our dwellings? It was done: and electricity shed its first fruits over the world.

Near forty years later, ten before the last century closed, a frog's leg freshly prepared for cooking, lying on a table in Galvani's house, on which was a charged electric battery, was observed to twitch convulsively when touched by a knife. Galvani took the hint, and after a series of experiments, thought he saw evidence of a new power in animal life, passing between the nerves and muscles. Volta soon disputed Galvani's theory of animal electricity, and set to work examining the conditions of the leg, its metallic connections and other circumstances. In pursuit of the simple truth, thinking that perhaps mere moisture might be an agent in the phenomenon, he placed a plate of silver on the back of a living frog, and another of zinc below, and on pressing gently, and bringing the plates into contact at one edge, the frog twitched all over, though no nerves were exposed. He next put the same metals together with only a moist piece of cloth or paper between, and, on connecting the two metals by a wire, observed at the moment of connection, an effect on an electrometer precisely like that caused by electricity. All that he required to produce the result, was a coin or disc of silver, (or copper,) a similar disk of zinc, and between the two, a disc of cloth, nearly as large, wet with salt water. He then added to the little triplet of silver, wet cloth and zinc, another triplet of silver, wet cloth and zinc, and another, and so on,

making a pile. With three or four such triplets in the pile, on touching one extremity of the series with a moistened finger of one hand, and the other extremity with a finger of the other hand, he felt a slight shock in his fingers, apparently of the same nature with that in the frog's leg: and as the pile increased in height, the shock increased; and moreover, he finally obtained a spark like that from the Leyden jar. It was light to the mind as well as eye. The movement of the frog was explained, while something very like electricity was evolved under extraordinary circumstances.

In this little pile—the voltaic pile, as it has been called—the first step was taken on a road leading deep into nature's arcana. Yet neither the world nor Volta then knew its future. Many, no doubt, were the contemptuous inquiries, "*cui bono?*" following a shrug at the shock felt at the finger-joints and elbows.

Others immediately after took up the line of investigation. The pile was changed into a trough containing a series of couplets of zinc and copper, alternating with narrow chambers filled with acid, in the order, zinc, moisture, copper, as used by Volta; and a brilliant series of developments commenced. The way had been prepared by the recent growth of the science of chemistry, which had made rapid progress since the discovery of oxygen, by Priestley, in 1774.

In experimenting with the battery, on bringing wires from the two ends into contact, intense heat as well as light was observed, melting or burning the wires:—*one new principle*, that this force will produce great heat.

Upon dipping the ends of these wires into a glass of water, bubbles of gas escaped from each, proved afterward to be the elements of water: hence, *another new principle*, that galvanism has the power of sundering the elements of a compound, or decomposing it. It was strange to most eyes, and nothing more; and to the question what is the use, there was little yet to show. Sir Humphrey Davy, pursuing this thought, obtained from potash, a metal afterward called *potassium*, that would float and burn on water; and from soda, another, *sodium*, almost as inflammable. But the quantities produced were very small, and there was nothing for the arts. It was observed, also, that on using in the battery the salt called sulphate of copper or blue vitriol, the metallic copper of the salt was abundantly deposited on the zinc, illustrating farther, this power in galvanism of decomposing compounds; but the fact was unproductive, except of inconvenience.

As years passed on and investigation continued, it was discovered that galvanism could make magnets out of any metal; that magnets could produce the effects of galvanism, give shocks and sparks, and decompose water; that electricity also could be made to decompose water, like galvanism. In fact, it became apparent that these three agencies were akin, and probably one in origin. But there was still heard the sneering "*cui bono*," which saw no good in studying truth for its own sake, and had no measure of its value but the moneyed return.

It is the glory of the arrangements in the physical world, that beauty and utility mostly go together. The former, is first and always reached, and is the boon to tempt the mind onward in research. By and by the practical comes forth in abundance, and then mind has its double reward. We have faith that the slow-growing tree, which for years is expanding in leafy beauty, will yet afford a rich return: at last the buds appear; then the flowers open out in their splendor; and finally, both beauty and utility oft-times reach their climax together, in the ripened fruit, one heightening the effect of the other. Such should be our faith in the study of nature; for however dry the work of him who delves, nature has treasures in profusion to reward the labor.

About forty-five years after the twitching of Galvani's frog, the time of blossom and fruit came; and such a succession of benefits from nature never before descended on the globe in any one ten years.

In 1837, Professor Morse, one of our own number, was already setting up his telegraph, bringing into its construction the well-known principles of the electro-magnet and galvanic battery; and now telegraphic threads, along which thought travels with almost the speed of light, are enveloping a large part of the globe.

About the same time, the fact of the deposition of copper from a copper salt, became a productive principle. It was found that copper could thus be deposited over an engraved plate, and a perfect copy made of every line or dot. The happy thought soon developed into a new art—that of electrotyping. A single engraved plate could thus be indefinitely multiplied, and the original retained unhurt.

But the art was not confined to this purpose alone. Books, till then, had been stereotyped by making a plaster cast of a surface of a page set in type, and then taking casts of lead in the plaster. Now they take the first cast in wax, cover its surface with powdered

black lead, and carry it to the galvanic battery. Thence, it soon comes out, a cast of the page in copper, far more perfect than the old stereotypes, more expeditiously made, and more durable. The Bible House in New York, is now full of electrotypes; they scarcely print from any thing else. The fine wood-engravings, so profusely adorning some of the Tract House publications, and many of the illustrated works and magazines of the day, are printed from electrotypes alone. Thus the great art of book-making, and therefore the whole world of mind, and all that is sacred as well as secular, are reaping results from a science that germinated first in that queer little pile of Volta, which in the opinion of the economists of its time, was of no earthly use to any body.

But if type and engraved plates, and wood-cuts may be copied, why not copy other things in the same way? In fact, the process is used for the reproduction of works of art; and thus immense establishments now manufacture medals, bronze statues or statuettes, and bas-reliefs, in a style of great beauty and perfection, and at moderate cost.

Shortly after the first electrotypes were made, it was observed that the deposition of silver or gold, through galvanism, on copper, and some other metals, served as a convenient mode of plating; and to-day nearly all the silvering and gilding on metal required in the arts, is done by electro-plating. Minutes now stand for the hours of the old regime.

Some years ago, it was thought that if electro-magnetism could move the machinery of the telegraph, and mark down or print off the passing thought on paper, it would also register the beats of a pendulum. Or, if so willed, it would repeat the beats of any *one* clock all over the land, wherever it was sent along wires for the purpose. And already, in some cities, they are beginning to distribute and sell *time* as they do *gas*, one single time piece *timing* the town, as one gas establishment *lights* it. At Marseilles, they are, this very year, putting time-pieces, thus fed, into all the lamps of the lamp-posts along the public streets, which may be read at night as well as by day.

To our own country belongs the honor of this application of science. At this moment, the astronomical clock at Cambridge beats time in all the railroad depots at Boston; and but a few weeks since, the Dudley Observatory at Albany, proposed to supply the city of New York with time, the observatory drawing upon the stars for its supply.

The astronomer has other higher uses for the subtle agent, for he makes it his private secretary, requiring it to register on paper, the time of his observations, and help map off the heavens. If a strip of paper have a straight, uniform motion, and as it moves on, just touches the point of a stationary pen or pencil, a mark is made on the paper, which obviously would be twice as long for two seconds as for one; and so on. If then, for every second, a mark an inch long were made, every inch would represent a second. Thus seconds may actually be converted into feet, and time may be measured by the yard-stick; or with a delicate scale, a second may be subdivided into tenths and hundredths of a second. This simple and ingenious idea, the astronomer applies to his purposes by means of a clock and a telegraphic apparatus; and now instead of counting the ticks of his clock, he touches a key at the moment of a transit, or other event in the heavens; this makes a check on the paper, and so marks the precise time, even to a minute fraction of a second. The observations thus made, are not only vastly more accurate than those on the old plan, but may follow one another with incredible rapidity; so that in one night, more work can be done than before in a month.

This invention, the work mainly of American mind, by which electro-magnetism has become the astronomer's most faithful assistant, is now introduced into some of the best observatories of Europe.

The difference of longitude between points over this continent, and between Greenwich and the observatories of Europe, has been ascertained by the same means, and with like accuracy. This, too, was an American suggestion. And when the telegraph wires now in progress are laid across the Atlantic, the difference of longitude between Washington and Greenwich will be as exactly known. Who imagined fifty years since, that the galvanic fluid would help us measure distance on the earth, and that the geographer would have cause to bless the lightning as well as stars!

With equal facility, this agent has been adapted, as I have said, to the fire alarm bells of a city. Where employed, one man may strike every bell in the city, though miles apart, at the same instant; and a slight movement of the finger is all the power he exerts; at one tap, the ringing begins, and it continues without further effort. At the same time, too, instantaneous notice of the place of the fire may be sent to every engine house.

The same agent is playing errand-boy in hotels, displacing the

brazen-tongued messengers that were regularly kept on file in the office.

All these,—and many more results might be added,—are developments from that unseen force which Galvani and Volta were the first to recognize, after the world was almost *fifty-eight hundred years old!*

In this review of the useful in science, I have left wholly unnoticed the beautiful results of photography, and other uncounted gifts of chemistry to the arts, and the contributions also from the departments of light, heat, and natural history, that are variously enriching the world. But I must stop here, my illustrations, for want of time. I think I have abundantly shown that this modern age far transcends the ancient world, through its obedience to the injunction, *Subdue, and have dominion;* that man has thereby grown in wisdom and power; that progress in science is hence demanded as our bounden duty. Every principle of our being prompts to its study: our love of the beauty and grandeur of truth; our eagerness for startling developments or novelties; our ambition as a nation to rise in wealth and honor; our very avarice: all urge us to search out nature's laws. And those whom I have the honor to address will also appreciate the still nobler sentiment, that God is here making displays of his glory, and giving lessons to man on a subject loftier than art, even his own transcendent wisdom in the great plan of creation.

Science is an unfailing source of good. And as the laws of God are universal, even more so than air and water, so every new development is destined to bestow some universal blessing on mankind. Complain not, if the reward be long delayed. Man has not the prescience that entitles him to declare any truth in nature useless, however barren to present view. The tree and fruit come from the germ; and no one will denounce the seed because the blossoms are not yet visible.

If evil appears mixed with the good, let us remember that it is so mixed in the heart of man, and this is its only source. The face of nature is as pure as the atmosphere of heaven, and if, in our looking, we see aught that is bad, it is a graft from tainted humanity.

The working of self-reliant mind, not the study of nature, has been the prolific source of error in philosophy and religion. Proud man, trusting to himself, looking within for knowledge, and hoping by simple, unaided thought, to fathom the depths of nature as well

as mind, has reached one error after another; and thus pantheism and other false systems of belief have been engendered.

Mind, through its intuitive principles, and its capacity of cultivation and development, is made for the contemplation of God's works and word; and it is our exalted privilege thus to be pupils,—pupils of the infinite God, himself our teacher and our study. For his works and his word are two revelations of himself which he has adapted to our finite natures:—the *first*, a manifestation of God the Creator, displaying his wisdom, power and beneficence; the *second*, a manifestation of God the Supreme Ruler, exhibiting his holiness and love, and having its consummation in the advent of Christ, who is "God with us," the light and life of the soul. In apprehending spiritual things, we thus are not left to ourselves; we even have besides this revelation, the aid of the ever-present Divine Spirit. And with regard to God's works, we search our own minds in vain for truth: but looking to the works themselves, we find wisdom welling up even at our feet. This wisdom is that we call *science*, the science of nature.

It is painful to witness the dread of this science that is so often displayed, when, as I have said, the real origin of mischief, as far as it is intellectual, is in that old method of philosophy which makes systems of nature out of baseless cogitations.

Geology, of all the sciences, has been most denounced for alleged infidelity: and yet it is the very one among them, that has come most valiantly and successfully to the combat against error. It is proving, what none other could prove, that God's hand, omnipotent and bearing a profusion of bounties, has again and again been outstretched over the earth; that no senseless development principle evolved the beasts of the field out of monads, and men out of monkeys, but that all can alike claim parentage in the Infinite Author; that the earth has been ordered through a long history, in its plant and animal life, its accumulating rocks and minerals, its rising mountains, shaping continents, and deepening seas, with reference to man, his whole intellectual and religious development. Tenfold power beyond that from any other source, is thus given to the evidence of a moral and spiritual purpose in creation; and this established, we have the highest proof nature can afford of a personal God over creation.

Science should not be feared. Her progress is upward as well as onward, to clearer and clearer visions of infinite beneficence. Her platform is not a shifting one. She stands on truth, looking

wistfully to brighter realms above. And if, while in eager gaze, her conceptions respecting regions yet unreached are vague, or in any way erroneous, each step forward is to a higher level, where she may resolve what before was dimly seen. Thus she rises from truth to loftier truth, dispelling the error that may be mingled with her deductions. Press her forward, then, with all your might; for in her progress, the finite is taking proffered strength from the Infinite. It is cowardly, it is wrong to God and ourselves, to doubt.

The Atheism which has long possessed much of the intellectual philosophy of man, may and will strive to use the developments of science for its ends; and in this evil world, a blighting influence from such a source will long be felt. But the course of research is tending to ward off the evil, and make science what by divine appointment she must be, the faithful handmaid of sacred truth.

A pestilential cloud has recently passed over the country, which has marked its track every where with infidelity. It was not a natural emanation from God's works, but the same in origin with the vapors that shrouded the world in the ages of superstition, when mind was oppressed by its own imaginings. Scientific men have often been blamed for a want of interest in the phenomena. But it was mainly power drawn from nature by faithful research, that annihilated those spirits, black, white, and grizzled, of olden time; and surely there can be no less hostility to the breed now. The height of the pestilence has passed; and the best preventive of another return we can offer, is a strong infusion of inductive science.

We have reason for gratulation, that our country is beginning to appreciate the importance of scientific culture. A general movement in its favor, is in progress over the land. From the east to the far west, from the north to the south, there is a rising voice calling for this knowledge that makes nature our helpmeet in industrial pursuits, as well as our instructor in lofty truth. Universities are planned in various States: more than one has been projected in New York State alone, and in her great city, a magnificent temple consecrated to industrial science now stands nearly complete. Endowments are made to this and that institution, to meet the urgent want. Six years since, the half century closed, and a large part of the semi-centennial sermons then preached, were mainly on the triumphs of science in the fifty years just passed; and although not so recognized, it was in fact a scientific jubilee. It was followed soon by the Crystal Palace exhibition at London, and then

another in New York, and others since in Europe,—all tending to arouse the attention of the world to the true basis of national greatness, the harmonious blending, under the highest intellectual culture, of Art, Science, and Religion;—Science bestowing her profusion of gifts on genial and pliant Art, and at the same time offering her first fruits to Religion; while Religion is pointing both Science and Art upward to the source of all knowledge, and guiding them in the way of truth and righteousness.

But while the necessity of instruction in nature-truth is appreciated throughout the land, it is not clear to all, what is the best mode of supplying the need, or, in other words, what kind of schools of science and art, the country demands.

It is plain that they must be of various grades. There may be the trade school for the child, especially such children as are objects of charity. There should be other schools for youth frequenting our institutes, and for journeymen in all the various trades of the country; and then still higher schools, where teachers shall be taught, which shall be head fountains of knowledge supplying the land with its engineers, its architects, its agriculturists, its thoroughly grounded mechanics, as well as its chemists and proficients in theoretical science.

In most of the schemes for these higher institutions which are brought forward, there are two prominent errors demanding brief consideration.

First, what is thought to be needed is the practical mainly. None of your theories, they say, but the practical, unaware that the practical rests upon the true scientific as its basis, and that the two must go hand in hand, as they are one in their aim, and parts of the same system of truth.

But, *secondly*, where science seems to be appreciated, there is a tendency to be content with a meager allowance; or, with careful regard to economy to get out of one man the duty of half a dozen.

In a small village, wares of all sorts, and only a little of each, are necessarily gathered into a single shop. In striking contrast with this appear the multiplication of warehouses and profusion of each kind of product found in a large city. America has always been to Europe, as regards its means of scientific instruction, like the country to the city. But are we always to remain a country village along side of Europe? With twenty-eight millions of population may we not yet have city privileges?

Even little Saxony, with a population less than two millions—

about the size of Connecticut, Massachusetts, and Rhode Island,—has a Mining School with thirteen professors, delivering lectures on Physics, Chemistry, Mineralogy, Geology, Descriptive and Practical Geometry, Mining Machinery, Metallurgy, the Blowpipe, Assaying, Mining Jurisprudence, Drawing, and the French Language, while the greatest number of Professors that in the American mind was ever dreamed to be necessary in such an institution is two: a professor of mining, who should also be a geologist and a mineralogist, and a metallurgical professor. Indeed these two distinct branches many would think might be in the hands of one, although no mining company would trust its furnaces to the mining engineer, or the sinking of shafts to the reducer of ores.

But Saxony, although so limited in teritory, has, besides this mining school, a University of one hundred and nine professors and instructors; also five schools of arts and design, with thirty instructors; and seventeen trade schools of the first grade, with ninety-three, in the country towns, of lower grades.

Saxony is a fair example of most European states. There is no counting of dollars as to the exact cost of educating boys per head, as if raising cattle, but a wise determination to have the best of educational institutions at any expense.

Russia, thought of by many as a land of semi-barbarism, has at St. Petersburg a school of mines with forty-three professors, which is furnished with splendid cabinets of minerals, ores, and models; and among the models, there are great subterranean rooms, showing the whole inner structure of mines, into which you may descend and examine the underground works.

There is also a school of forestry, having in view the culture of trees, which has its immense gardens or forests of both indigenous trees and species brought in from various parts of the world, besides cabinets of all kinds of woods; and it controls a corps of emissaries, which it dispatches over the land for the care of the trees of the empire.

In addition to these, there are seventy-five subordinate mining establishments with two hundred and forty teachers and near seven thousand scholars; also, an extensive central school of agriculture, with various subordinate establishments; also another central school of industrial mechanics, and chemistry; another of engineering; and so on.

There are certainly some things in which we are *not* ahead of the rest of the world. And shall we not look abroad and learn wisdom? It is well known that to meet the demands of the age,

and secure success, broad plans and large capital are required. So in educational institutions, like those of which we speak, two or three associated professors may do something: but a small school will only creep along, and may be crushed by ambitious rivals. We shall find, however, a different result, if the school expand to an efficient size:—if it become a place, where the agriculturist can obtain a complete agricultural education, from chemistry, geology and the nature of soils, to the practice of farming and the raising of animals; where the mechanic may learn all that pertains to the metals and other material in machinery, all the applications of chemistry he requires, the laws of motion, the methods of applying power, and whatever is novel or instructive in the most recent patents; where those following the chemical arts, shall be equally well supplied with a good foundation, and principles as exemplified in different branches of manufacture; where the architect and engineer shall find instruction on building material and cements, in the mathematics of arches, bridges and structures generally, in physics, the use of instruments, practical engineering and drawing, in the principles of taste and the history of works of this and past times; where, too, those who would pursue science for its own sake shall be aided in acquiring all that science can teach, that they may go yet deeper in research, and bring to light other facts and principles to increase the wisdom and strength of toiling man.

The theoretical and practical should go together and on a scale of magnitude sufficient to produce results of value. Let each one whose pursuits bear on the arts or sciences compute what his special department requires, and then let all the results be combined, the decision will assuredly be that we need for efficiency a great institution, something corresponding to the country in its extent and enterprise.

Why is it that France, without mines and with few resources, is yet one of the wealthiest nations of the world, and in advance of others in the quality of many of her manufactures. France knows that there is inexhaustible wealth in nature's laws, and encourages science among all grades in society. She has her many schools of science in which the practical and theoretical are conjoined, and all under thorough organization.

At Paris there is the great Central School (L'Ecole Centrale,) the Conservatory of Arts and Trades, the School of Engineering, the School of Mines, the Polytechnic School, besides the famous Garden of Plants, an institution with vast museums and

numerous instructors in all branches of science. Subordinate to these, there are schools for special departments distributed over the empire, meeting the wants of every particular manufacture in all its details.

The French government directs special attention to the art of design and improvement of artistic skill and taste among the people, having the wit to see that taste expended on iron or copper may multiply many fold its prime value, while mere labor adds but a small percentage. The nation encourages especially chemical investigation, and reaps one of its rewards in having dyes that claim universal admiration, throwing into bad repute our Merrimack imitations; and having colors for porcelain, that also reproach us. These are two out of many examples that might be mentioned.

Prizes also are annually offered for new discoveries or investigations, and every incentive thrown out to scientific activity. From this encouragement of the arts and sciences proceeds very much of the strength and wealth of the French nation.

England saw the contrast to her disadvantage at the Crystal Palace exhibition in London, and has since organized the Department of Science and Art among the departments of the government, designed to carry out a system of scientific and polytechnic instruction over the land; and to this end £80,000 ($400,000) were appropriated for the last year.

A moment's consideration will help us to comprehend the working of such a system of education. It is to be observed that the plan we contemplate, would include mathematics to its highest departments and through its various applications; the different branches of physics and chemistry; geology in its grandeur as a record of the past, and also its developments respecting mines, building materials and soils; astronomy; mineralogy, zoölogy, botany; the logic and philosophy of the inductive sciences; modern languages, and their connection and origin; geography in its relations to climate, history, commerce and the progress of nations; drawing and the history and criticism of art; all these, besides the practical arts and sciences in their diversity.

In the first place, then, the institution in view would open a wide range of university education to those who have not the requisite Latin and Greek to pursue the ordinary college course. The plan so blends the departments of knowledge taught, that the student, if he remains long enough to take the benefits offered, will come forth,

not shaped only for a single narrow channel of life, but with cultivated intellect and broad views of the world.

In the second place, it would make proficients in special departments fitted for stations of responsibility, men, who have acquired that wide range of principles and familiarity with their operations, which will render science a tool in the hand for farther progress. You now rarely find one among our common mechanics who knows the various qualities of the metals he is working with, or the laws of motion connected with machinery, or what is new or old, exploded or accepted, among inventions. And *one* consequence is, that the man, although of much general intelligence, is confined to his single thread, year after year: *another*, that his talents, if he have ingenuity, will often be wasted on worthless inventions, or efforts to work out what was long since known, or perhaps in laborious pursuit after that mechanical *ignis fatuus*, perpetual motion. Instead of starting with existing knowledge to work successfully to a higher level, he is groping in the darkness that was long since dispelled from the walks of true science and art.

There has recently been a "perpetual motion" machine in this region. The inventor knew the deception he was practising. But a large part of the mechanics that saw it were more than half satisfied that the great problem had been here solved, and incredulous science proved at fault. But should the secret be divulged, they would be surprised to find how they were deceived. All the arts afford similar illustrations of wasted means and misspent powers.

Again, such an institution would furnish men able to teach and spread sound knowledge around them, and so raise the standard of art education, besides protecting multitudes from follies and foolish expenditure.

Again, it would call into play the latent talent of thousands that now tread only in beaten paths, and open numberless channels of labor almost unoccupied. It would cultivate general taste, which is becoming more and more important in all our manufactures. It would tend to render the laws of nature universal in their benefits, by placing them at the command of the many over the land. With such results, the institution would assuredly become a chief source of national wealth and prosperity.

It is a striking fact, illustrating our poverty as an industrial people, that Mr. Goodyear, now in Paris, could not find the taste or artists here, able to design or make the articles which he required in the development of the india rubber manufacture.

There is, too, the still wider fact, that very many of the arts are pursued in this country only through artists imported from Europe.

We *should* have our own centers of strength and vitality; and this we aim to secure. With a plan of education of the kind explained fully carried out, the country may hope to take a stand on terms of equality with other civilized nations.

Here is a system of internal improvements that looks deeper than to the welfare of harbors and rivers. It strikes at the working mind of the nation. It takes its station above the common and high schools, to receive the youths there prepared with the elements of knowledge, and fit them for positions of honor and usefulness in the sciences, commerce, manufactures, agriculture, and other walks of life.

The results looked for, will not be the outflow of the University in itself alone. For such University schools produce, as a natural consequence, subordinate schools. The lower trade schools, where the details of each trade shall be taught, will multiply over the land in every town or county, as part of the fruits of the system. The university must first exist to afford the teachers for such schools. Once in full action, a flow of benefits will proceed from it that will cover the continent.

I have said that the age was calling for schools of science, and that many attempts are making through the land to meet the call.

The question with us is, shall this be the great seat of learning for the country? Shall the institution which took root with almost the first germs of civilization on the continent, and which has spread its branches widely, so as to be second to none in its compass and influence, still continue to expand with the expanding mind of the world? Or, shall we be content with the past, and see others imbibing the spirit of the age, and through the new vigor derived, rise beyond us, till like other shaded plants, Yale shall begin to dwindle, her laurels fade?

Ten years since, the Department of Philosophy and the Arts was projected (and the following year instituted,) by the Corporation of Yale College, to cover special instruction in general and practical science and the higher branches of literature. At that time, in 1846, the Yale School of Science, embracing chemistry applied to agriculture and the arts, was commenced, under Professor Benjamin Silliman, Jr., and Professor John Pitkin Norton, the latter, to our grief and great loss, since deceased. They worked

zealously, and for naught but the satisfaction of promoting the spread of scientific knowledge; for the income of the year never exceeded its expenditures. This school has continued its existence, and in it, many of the best young chemists of the land have taken their first steps in science. A professor of engineering has since been added; and already over 300 pupils have been here under instruction. As the school now stands, it has a professor of chemistry applied to the arts, a professor of agricultural chemistry, one of metallurgy, one of engineering, and through its connection with Yale College, one of geology, mineralogy, and general zoölogy; in other words, as is seen, one professor corresponds to a whole school of professors abroad. Moreover the school is without endowment. Still, there is here an organization, embracing nearly all that is required in theoretical science, with a part of the practical; and though incomplete, it has had a good measure of success.

The present organization only needs expansion, and adaptation to broader purposes; that is, a full corps of professors, so that the several sciences and arts shall all be subjects profoundly, and not one-sidedly taught; and it is important that there should be included that thorough instruction in the philosophy of geography, history, language, taste, and inductive reasoning, which will make the graduate an educated man, and an honor to the university. Several gentlemen of the College faculty, and others on the ground, are ready to coöperate toward this great end.

As the different departments contemplated in the plan are all embraced in one school, each does not require an independent corps of teachers; for a professor may instruct in half a dozen different sections, without much increased labor. A full organization, therefore, could be accomplished with only a moderate number of men, not much exceeding the corps of a school for a single department abroad.

The execution of the proposed plan, requires also a building, containing laboratories, lecture-rooms, and a museum of specimens and models; it needs, too, a farm for the agricultural department.

The museum, moreover, should be a spacious one, containing collections connected with all the subjects taught in the school: specimens in natural history; seeds, soils, implements and plans for the section of agriculture; models of bridges, arches, buildings, roads, aqueducts, samples of materials for construction, and a cabinet of physical apparatus, for the sections of engineering and architecture; collections of machines, models of new inventions, involving important principles, and collections of materials and im-

plements for the section of industrial mechanics, collections of art-products in all their stages of perfection, and their many varieties; collections of ores, and metallurgical products, models of mines and furnaces for the department of mining and metallurgy. In fact, the museum should lecture to the eye, and thoroughly in all the sections represented, so that no one could walk through the halls without profit. It should be a place where the public passing in and out, should gather something of the spirit, and much of the knowledge, of the institution.

Already, through the liberality of one of the citizens of New Haven, a fine lot has been set apart conditionally for the school,—one more beautiful or more convenient could not be found in or about the city. The condition is simply that of occupation and our having the means of success. No city in the land is a more favorable place for such an institution. The presence of the College, her large libraries and mineral collections, her professors and means of instruction, give it a vast advantage, being a portion of the capital of the school greater than we can estimate.

There is another need, which has not been alluded to, as it requires its own liberal foundation. I refer to an astronomical observatory. Yale, to this time, has none. The temporary arrangement on College grounds, where the Clarke telescope stands, merits many honorable words for directing early attention to this subject, and for its able contributions to astronomical science. But it is not an observatory, and has not been so regarded; and one fine instrument, the gift to the College of William Hillhouse, Esq., of this city, is stored away for want of a place to mount it, while an astronomical clock, from the same generous donor, is wasting time in the Library. May Yale, which had an early start in this department, be unsurpassed in her equipments, whenever the time for action comes. The regions of space to their farthest penetrable limits, will then be within her range of vision and study.

The department of philosophy and the arts, here instituted to embrace these various subjects, stands on the same independent basis with that of theology, law or medicine. While each is alike independent of the College proper, or academic department, one mantle covers all, and the same seal and the same honored name are affixed to all the diplomas.

My remarks thus far have had special reference to scientific courses of study, since these are less generally understood, and are more neglected among us, than those of any other branch of education. But the plan does not stop here: only a little wider expan-

sion of the scheme,—such as is contemplated, in fact,—and it will cover the highest branches of literary as well as scientific education, adapted to carry forward the graduate of the College, through a full university system of classical or other studies. Let there be a one or two years course of lectures and instruction arranged, which shall include general history, philology, ethnology, belles lettres, the history of philosophy, and other intellectual studies, and the number of resident graduates would greatly increase, and a new era dawn upon American learning. Not till this is accomplished, will the department of philosophy and the arts projected, become a realized fact. Not till then, can we hope to prevent our youth from seeking in the atmosphere of Germany the knowledge for which they yearn. The tide in that direction is on the constant increase. In one year, out of a dozen students in the Yale scientific school, half of them left for Europe; and the walks of literature illustrate the same fact. It is surely time for earnest and determined action.

GENTLEMEN OF THE ALUMNI:—

The plan is before you. It bears its own evidence that in the will of her men and the breadth of her aims, Yale is determined to be up to the times. The desire is manifest that the College, as it now stands, shall not longer mark the limit of American training in literature or science, but that higher paths be laid out, and broader fields surveyed and occupied.

Notwithstanding the clouds about our political horizon, we believe that America, free America, is to be the hope of the world; that she will yet take the lead among the nations, in population, wealth, education, benevolence, and all that adorns humanity. And in this growing nation, we see our revered Alma Mater, great also,—unexcelled; in the number of her students, beyond every other; in active interest in the welfare of her youths—but we would not boast. The first university in the leading nation of the globe,—dare we hope it? Why not let it so be? Why not have here, in this land of genial influences, beneath these noble elms, that seem like a realization of the classic shades of Greece,—but where a higher philosophy than that of Socrates, the philosophy that centers in Christ our chiefest glory, is the pervading spirit,—why not have here, THE AMERICAN UNIVERSITY,—where nature's laws shall be taught in all their fullness, and intellectual culture reach its highest limit! The affluence of nature should be our model: and if so, the greater the glory to this seat of learning, and the vaster the blessing to our country and the world.

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PLAN OF DEVELOPMENT IN THE GEOLOGICAL HISTORY OF NORTH AMERICA.—WITH A MAP.

BY JAMES D. DANA.

ON other occasions, I have discussed at some length, the outline and surface features of the continents, the parallel courses of island groups, and the relations between the structure of the continental borders and the extent of the adjoining oceans; and I have endeavored in connection to elucidate the great principle of geological dynamics, which is at the basis of these characteristics of our globe.* I propose at this time to point out the relations between the operations of this principle or agency and the special geological history of the North American continent.

To render this application of the subject intelligible, it is necessary to review briefly the fundamental facts just alluded to. For this purpose, I would direct attention to a Mercator's Chart of the World, (see plate) on which the whole is open to examination—such a chart being a minature representation of the facts themselves, and the order observed among its parts, the syllables which spell out the principles.

In the first place, note the two great oceans, the Alantic and the Pacific—both widening south, and coalescing in a vast ring of ocean around the south pole, while narrowing north and uniting in a small arctic sea. The Indian Ocean is a third north and south ocean: but it reaches north only a little ways beyond the equator.

As the Atlantic is less than half the breadth of the Pacific, so the American continent is less than half the breadth of the great Orient, including Europe, Asia and Africa. It is seen also that while the North Atlantic treads off to the northeast, and the whole Atlantic is a zigzag channel with a main *northeast* course, the Pacific is a *northwest* channel, its longest diameter (represented by the line M M), being at right angles nearly with the trend of the Atlantic (N N). This longest diameter, moreover, corresponds with the general trend of the Pacific islands; for these islands have a nearly parallel course all through the ocean, the New Hebrides, Kingsmills, Samoan, Tahitian, Marquesas and Sandwich islands, lying in approximately parallel lines.†

* Am. Jour. Sci., [2], ii, 335, 352, iii, 94, 176, 381, iv, 88; Report, Geol. Expl. Exped., 756 pp. 4to., 1849, pp. 11, 414, 429; Proceedings Amer. Assoc. vol. ix, Providence Meeting, 1855, and page 305 of this volume.

† I may here add, what I have elsewhere explained at length, that the trends of the Pacific, while having a general correspondence of direction, pertain to two systems, one the Central Pacific, the other the Australasian. The Central Pacific begins in the Paumotu Archipelago, or rather still farther east, in Easter Island and Gomez; is thence continued on a west-northwest course, by the Society Islands, and the Hervey Islands more south; thence by the Samoan and Fakaafo groups; thence more northwesterly by the Vaitupu and Kingsmills, to the Radack and Ralick groups,

In the body of New Zealand, however, and some other parts, the transverse trend of Eastern America is represented.

Now what is the relation between the borders of the continents as to features and structure, and the extent of the oceans?

1.. Look first to North America. Observe the general direction of the coast conforming to the prevalent trends of the globe, the northeast and northwest, and thus giving it its triangular form. See the low Appalachians facing the *small* Atlantic, the lofty Rocky Mountains, mostly a double line of heights, facing the *broad* Pacific, besides a second towering range, the Cascade and Sierra Nevada, nearer the sea. May we not say, *As the height of the Appalachians to the size of the Atlantic, so is the height or extent of the Rocky range to the size of the Pacific*?

In South America, there is the same relation—the low Brazilian mountains on the Atlantic side, the lofty Andes on the Pacific, and the latter exceeding the Rocky Mountains as much as the South Pacific exceeds the North Pacific; so that we may make another proportion, *As the height of the Rocky Mountains to the North Pacific, so is the height and boldness of the Andes to the South Pacific.*

In the Orient, the mountains towards the Atlantic, or those of Europe, are low and limited, compared with the long and lofty ranges of the Pacific side; and these last are inferior to the Himalayas, the sublimest heights of the world, which face the Indian ocean—a large and open ocean, while the Pacific towards Asia is much encumbered by islands.

In Africa, the loftiest and longest mountains are those of Abyssinia, on the east, facing the Indian Ocean, some of whose ridges are eleven to fourteen thousand feet in height, and one

which run nearly north-northwest; making thus a great sweeping curve, of several strands, over 6000 miles long. The Sandwich or Hawaian islands on the north side of the equator (2000 miles in whole length) is the opposite or northern side of the same system, slightly curving with the convexity to the north: while the Marquesas and the Fanning or Washington group lie along the axis of this great Central Pacific area. The other system is concentric around Australia, (New Holland). The line of new Hebrides, near northwest in course, is continued in the Salomon Islands, and New Ireland, becoming gradually east and west in the Admiralty Islands, north of New Guinea. The line of New Caledonia, another curving strand in the system, is continued in the Louisiade group and New Guinea, and becomes east and west in western New Guinea. The foot of the New Zealand boot, and the Coral Archipelago between New Caledonia and Australia accord with the system. The position of these lines concentric around Australia correspond with the idea that the position and extent of this continent, has had some influence in determining the directions.

These two systems, the Central Pacific and Australasian, though so distinct, are yet bound together in one. For while the great central range has its main course along the Kingsmills and Radack groups, it sends off at the Kingsmills, a western branch, the Carolines, which is actually parallel with the lines of the Australasian system.

The transverse trend of New Zealand, which is continued in the Friendly Islands north, is the correlate of the northwestern, the two having a mutual dependence, and together distinguishable in many groups of islands as well as in the features of the Continents.

peak near the equator is 20,000 feet. In Australia, the Australian Alps, as they are called, are on the east fronting the Pacific, here the wider of the bordering oceans.

Thus all over the world, the highest mountains stand fronting the largest and deepest oceans; and the "rule of three" statement of the fact scarcely conveys a wrong impression.

2. We observe further that the coasts are in general so turned as to face the widest range of ocean. The Appalachians with the neighboring coast do not face northeast towards the European continent, but southeast, towards the great opening of the Atlantic between America and Africa. So on the west side of North America the Pacific coast faces, not towards Asia, but southwest, where the broadest range of ocean is before it.

3. Consider now a little more closely the structure of these ocean borders. How is it as to the effects of heat or volcanic action?

In North America, on the side of the *small* ocean, the Atlantic, we find metamorphic rocks, some trap dykes, and a few tepid springs. On the side of the *great* ocean, the Pacific, all these phenomena occur, and besides, some of the grandest volcanoes of the globe, while basaltic floods have buried out of sight almost all other rocks over a considerable part of the country. Mount St. Helens, Mount Hood, Mount Shasta, and a dozen others, twelve to eighteen thousand feet high, make a majestic file of fire mountains not yet wholly extinct. May we not then say, *As the size of the Atlantic to the action of heat on the Atlantic border, so is the size of the Pacific to the action of heat on the Pacific border?*

In South America, there is a direct repetition of the same facts on a still grander scale: the Brazilian side, with metamorphic rocks and no volcanoes; the Pacific side, with volcanic heights of 20,000 feet and upward.

In the Orient, there are some small volcanic operations on the Atlantic side; but an unnumbered host down through Kamtschatka, Japan, and the islands south on the Pacific side.

In Africa, there are great volcanoes in the Red Sea and the lofty Abyssinian mountains, and only a few on the east, in the Gulf of Guinea, where, in fact, the continent opens on the Southern Ocean and not simply on the narrow Atlantic; the volcanoes are at the junction of the two lines, in or near the Bight of Biafra.

4. Again, these effects of heat are confined mostly to the region between the crest of the border mountains and the ocean, and are most intense towards the coast line. Thus the crystallization or metamorphism of Eastern North America, from Labrador to Georgia, is strongly marked towards the ocean, and diminishes going westward. So on the Pacific side: the great

volcanoes are not on the east or landward side of the crest, for there is not a volcano on that side, but on the seaward side, and not very far from the ocean. Thus we may almost say, *The nearer the water, the hotter the fire.*

5. Again, the mountains that make the borders, consist as is now well known since the surveys of the Professors Rogers, of rocks that have been pressed up out of place into a series of immense folds, like the folds we may make in paper by pressing laterally; only the rocky folds are many miles in range and of mountain height; and these folds or plications and displacements are most numerous towards the ocean, and are parallel nearly to the ocean. Hence again, *The nearer the water, the vaster the plications of the rocks.*

6. Over the interior of North America, there are not only no volcanoes, but there never have been any since the earlier Silurian, as shown by the absence of their remains among the strata; and this is so, notwithstanding the abundance of salt water over the regions in those ancient times. Over the interior of Asia there are no volcanoes, as is well known, except the three or four in the Thian-Chan Mountains. The great volcanic belt of the Orient stands out a short distance from the water-line of Asia, in the Japan range of islands, thus directly edging the oceanic basin; for the intervening region of shallow waters is properly a submerged part of the continent.

7. In contrast with this non-volcanic character of the interior of the continents, the islands of the oceans, it should be remembered, are all volcanic where not coral, and those of coral probably rest on a volcanic basis. Dhwalagiri, in the Himalayas, 28,000 feet high, is granitic; and surely we might have looked for some granitic peaks among the central islands of the oceans: but there are none.

At the same time, as others have remarked, the transverse seas which divide the Northern and Southern continents, the East Indies, the Mediteranean and West Indies, are characterized by volcanoes.

If then, the typical form of a continent is a trough or basin, the oceanic borders being raised into mountains; if these borders are so turned as to face the widest range of ocean; if the height of these border mountains and the extent of igneous action along them is directly proportioned to the size of the oceans,—the Pacific, accordingly, being girt with great volcanoes and lofty mountains, while the narrow Atlantic is bounded by smaller heights and but few volcanoes; if, moreover, volcanoes characterize the islands of mid-ocean and not the interior of the continents: What is the legitimate inference?

Most plainly, that the extent and positions of the oceanic depressions have some way determined, in a great degree, the fea-

tures of the land; that the same cause which originated the one, impressed peculiarities on the other; that the two had a parallel history through past time—the oceanic depressions tending downward, the continents upward; in other words, that they have both been in progress with mutual reaction from the beginning of the earth's refrigeration. The continents have always been the more elevated land of the crust, and the oceanic basins always basins, or the more depressed land.

We thence learn that the profounder features of the earth were marked out in the earliest beginnings of geological history, and that the whole subsequent progress has been a working on this basis. Other and more direct evidence of this fact I alluded to in my address before this Association last year—evidence derived from the extent and nature of the Potsdam sandstone, the earliest of the Silurian strata, showing that this primal rock was laid down over a large part of North America by a sea which just bathed its surface—thus proving that the continent was already made, and indicating in part its water level.

The relation between the extent of the oceans and the border features of the continents, which has been pointed out, is not simply a relation of fact, but of effect and dynamics, pointing to a unity of cause. The one cause is assuredly not in the waters of the oceans, for these are inert: they cannot bake rocks, light up volcanoes, fold the heavy strata, and make mountains. The cause is no paroxysmal force, exhausted in a temporary freak of nature. It is some profound, systematic, untiring force, which in its slow movement, has counted centuries as if seconds. The Appalachian range is one mark of its power; but not the result of a fitful heave: on the contrary, a work of time, and time so long, that the resisting strata could bend in many plications without being reduced to chaos; so long, that New England and regions south, which entered the period of catastrophe as a territory of sedimentary beds, came forth at last a region of granite, gneiss and crystalline schists. Most of the mountains of the globe, for the reasons stated, we must regard as other effects of this fundamental cause; and it is therefore no matter of surprise that they should have in general a common system of structure.

A unity of cause there must be for the great phenomena of geology. Such is nature in all her departments. Details are the means by which we penetrate to the deep-seated cause; and when that cause is once reached and fully apprehended, the details have new interest from the harmonious relations thus developed,—as the leaves and twigs of a tree derive their grandeur and the most of their beauty from the rising trunk and spreading branches to which they are subordinate, and with which they are in perfect harmony.

What then is the principle of development through which these grand results in the earth's structure and features have been

brought about? We detect a plan of progress in the developing germ; we trace out the spot which is first defined, and thence follow the evolution in different lines to the completed result: may we similarly search out the philosophy of the earth's progress?

The organizing agencies in the sphere are—

1. Chemical combination and crystallization.

2. Heat, in vaporization, fusion, and expansion, with the correlate force of contraction which has been in increasing action from the time the globe began to be a cooling globe.

3. The external physical agencies, preëminently water and the atmosphere, chiseling and moulding the surface.

4. The superadded agency of life.

Of these causes, the first is the molecular power by which the material of the crust has been prepared. The third and fourth have only worked over the exposed surface. But the second, while molecular in origin, is mechanical in action, and in the way of contraction, especially, it has engaged the universal sphere, causing a shrinkage of its vast sides, a heaving and sinking in world-wide movements. Its action therefore, has been coextensive with the earth's surface throughout the earth's history. If a power at all, it has been a dominant power in the great changes, and in connection with the profound structure of the crust received through consolidation, it has wrought out the earth's lineaments, varying them with her years from the first featureless sphere to the bold expressiveness and wrinkles of age. This is the cause that most concerns us at this time.

There must be system in the intimate structure of the crust. For if it was once fluid, and is now one or two scores of miles thick, all this thickness beyond that of the first film has been produced through gradual, exceedingly gradual and prolonged cooling, adding, by downward increase, to the solid surface arch: and if ice over a pond when thickening in this same way by additions downward to the surface film takes a crystalline texture perpendicular to this film, as has been proved, we may safely infer that the crystallization of the earth's crust as it slowly thickened would have taken a regular structure, and the more surely since we know that the mineral feldspar, which gives a cleavage structure to granite, is the prevailing mineral in all igneous rocks. Thus we approach some explanation of the prevalence of two great systems of trends in the features of the globe. But this subject we pass by, to the one which more immediately concerns us—the surface features of the continents.

The contraction to which I have alluded, going on after a crust was formed over the earth, would necessarily fracture, displace, or wrinkle the crust, as the same cause, contraction, wrinkles a drying apple. The large rind is more than sufficient for the contracted sphere; and the drawing downward of some parts

must cause the bulging of others. If any large areas of the crust were sinking more than the rest, this very subsidence would necessarily push up the borders of these areas into angular elevations or folds; and it follows necessarily,—the larger these areas the higher the border elevations.

These are the simple principles. The oceanic basins are these areas of greatest subsidence; and hence would necessarily flow the law, already established as a matter of fact—the larger the ocean, the higher the mountains on its borders, the deeper the fractures and displacements there, and the vaster the outflow of internal heat and lavas. The size, therefore, of the oceans, that is, their extent and depth, is relatively a measure of the force exerted on their sides.

The wrinkles or elevations on the globe seem large when man measures them by comparison with his own stature. But a section of the land, true to nature, corrects this misapprehension. In a section of the North American continent, drawn to a scale twelve feet long, one-ninth of an inch will stand for an altitude of 10,000 feet; one-sixteenth of an inch for the White Mountains, and about three-tenths for the Himalayas.

After this review of principles, let us now turn our attention to North America and seek out its plan of development.

I. The triangular form of the continent has been noted and its simple ocean boundary: and it should be observed that the continent is set quite to the west of South America, so as to possess this simplicity of boundary and therefore of moulding forces in its highest perfection.* The small Atlantic on one side, and the great Pacific on the other, indicate approximately the relative amounts of force from the two directions, the southeast and southwest, during the progressive ages of the history;—that to the eastward the power was comparatively moderate, gently folding up the Appalachians, and to the westward it was strong and mighty, even to the raising of the Rocky range and opening the great volcanoes of Oregon. We thus learn, with a degree of precision not to have been anticipated, the direction and efficiency of the great organizing forces.

Glance now at American geological history from this point of view, and consider where was the first germinant spot of the growing continent, and what was thence onward the course of development under the influence of this agency.

The earliest spot or primal area will be that of the Azoic rocks, the first in the geological series. Such an area (see Chart, A A A) extends from Northern New York and Canada, north-west to the Arctic Ocean, lying between the line of small lakes (Slave, Winnipeg, &c.) and Hudson Bay. East and west, it dips under

* The contrast with Europe in this respect is striking, and accounts, as I have said, (Address, &c., p. 311,) for the greater simplicity of North American Geology.

Silurian strata (S S;) but it is itself free from superincumbent beds, and therefore, even in the Silurian age, it must have been above the ocean. And ever since, although subject, like the rest of the world, to great oscillations, it has apparently held its place with wonderful stability, for it is now, as probably then, not far above the ocean's level.

This area is central to the continent; and, what is of prominent interest, it lies parallel to the Rocky Mountains and the Pacific border, thus proving that the greater force came from that direction in Azoic times, as well as when the Rocky Mountains were raised. Thus this first land, the germ or nucleus of the future continent, bears in itself evidence with respect to the direction and strength of the forces at work. The force coming from the Atlantic direction has left comparatively small traces of its action at that time. Yet it has made its mark in the Azoic stretching through Canada to Labrador, in the dip and strike of the New York Azoic rocks, in the direction of the channel of the St. Lawrence and the northwest coast of Lake Superior, and probably also in the triangular form of Hudson's Bay. Against this primal area, as a stand-point, the uplifting agency operated, acting from the two directions, the Atlantic and the Pacific; and the evolution of the continent took place through the consequent vibrations of the crust, and the additions to this area thereby resulting; the ocean in the meantime pursuing its appointed functions in the plan of development, by wearing exposed rocks and strewing the shores and submerged surface with sand, gravel or clay, or else growing shells, corals and crinoids, and thus storing up the material of strata and burying the life of successive epochs.

These long secular vibrations, movements by the age rather than day, dipping the surface and raising it again in many and varying successions, were absolutely essential to the progress. Had the continent been stable, there could have been no history, no recorded events of changing life and alternating deposits: all would have been only a blank past. These forces, therefore, working mainly from the southeast and southwest, were actually organizing forces, essential to the completion of the continent,—to the production of its alternations of limestones, shales, sandstones and conglomerates, and its sweeping catastrophes burying the old preparatory for higher forms of life:—the continent in the course of these movements, being at one time, it may be, just beneath the ocean's surface, and having beds of sand and gravel accumulating under the action of the waves; then in somewhat deeper and clearer waters, with limestones forming from coral or crinoidal plantations or the growth of shells; then, perhaps, rising from the waves, bringing death upon its sea tribes in one universal desolation; then, sinking slowly in the waters

again, and varying in its accumulations from sandstones to shales, pebble beds or limestones, with the depth and the currents; and then again above the tides, although destruction to all the life of the ocean was in the movement; and, perchance, lying in the open air for an era, to receive the mists and rains and sunshine, and become luxuriant through new creations with broader prairies than now cover the West. Alternations like these were again and again repeated, as geology has shown.

Through these means, the continent, which was begun at the far North, a region then tropical but afterwards to become inhospitable, gradually expanded southward, area after area as time moved on being added to the dry land.

First, as the facts show, the Silurian deposits of Canada and the North, adjoining the Azoic, were left above the sea, for these rocks there are not overlaid by later beds; and, therefore, were not the sea-bottom of later seas. Next, the adjacent Devonian were added to the main land as far south as Southern New York and around by the west; for, as the New York geologists have shown, the carboniferous beds which come next do not reach into that State. By the time of the Jurassic period, the continent had expanded much farther to the southward, for the carboniferous rocks over the land were out of water, their beds having already been folded up and elevated in the Appalachians. The red sandstone of the Connecticut Valley and of the Atlantic States from New York to Alabama leave little doubt as to the water line of that era. In the Cretaceous period the continent had farther expanded along the Atlantic; but in the Mississippi Valley the Mexican Gulf still extended north even to the head waters of the Missouri. Next, as the Tertiary opened, the continent had yet more widely enlarged its bounds, south and southeast; and if the waters of the Mexican Gulf for a while claimed a place over some part of the Nebraska plains, as late observations suggest, by the close of the period the continent in this direction had nearly reached its full maturity. These steps of progress are indelibly marked in the position, and obvious seacoast, off-shore or estuary origin of the Jurassic, Cretaceous and Tertiary beds of the country.

Passing towards the Pacific, we find evidence in the carboniferous limestone that the Rocky Mountains were mostly under shallow water as the Carboniferous age opened, the mountains themselves unborn. Later in the Cretaceous and Tertiary periods, as the rocks towards the coast testify, the continent had extended far to the southwest, and was nearly complete in that direction, as well as to the south and southeast.

Thus the enlargement went on to the southward, each period making some addition to the main land, as each year gives a layer of wood to the tree. Not that this addition was free from

oscillations, causing submergences, for these continued long to occur; but the gain, on the whole, was a gain—a progress; and the moving ages made the accession a sure and permanent gain as the continent became more stable.

II. But in the statement that the growth of the continent was to the south, southeast, and southwest, we assert only the most general truth respecting it. The continent has its special features as much as any being of organic growth, and the elimination of these features is to be traced to the same system of forces. The Appalachian range on the east, the Rocky Mountains and the subordinate chains on the west, the lower lands and lakes of the interior, all in systematic relation, are the more marked of these features; and the vast river systems, with the broad alluvial flats and terraced plains, the wide spread drift, the denuded heights and channeled slopes and lowlands, are subordinate peculiarities of the face of the continent.

The Appalachian range of heights, as I explained a year since, was commenced in the Silurian age, and even earlier long before a trace of the mountains had appeared.* The force from the southeast, in the dawn of the Palæozoic era, had made the Appalachian region generally shallower than the Mississippi valley beyond. The vast sandstone and shale deposits of the region bear marks in many parts of sea-shore action, while the limestones which were forming cotemporaneously farther west, indicate clearer and somewhat deeper seas; and the patch of Azoic in northern New York, lying at the northern extremity of part of the range, points to an anterior stage in the same course of history; so that, in early time, long before there were mountains, the future of the continent, its low centre and high borders, was foreshadowed. We can hardly doubt that the region of the Rocky Mountains was in the same condition, in the main, with that of the Appalachians. Moreover, these borders, or at least the eastern, for ages anterior to the making of the mountains, were subject to vastly greater oscillations than the interior; for the Silurian and Devonian sandstones that occur along from New York to Alabama are of great thickness, being five times as thick as the limestones and associated deposits of the same age to the west. A limestone bed, moreover, is of itself evidence of comparatively little oscillation of level during its progress.

We hence learn that in the evolution of the continental germ, after the appearance of the Azoic nucleus, there were two prominent lines of development; one along the Appalachian region, the other along the Rocky Mountain region—one, therefore, parallel with either ocean. Landward, beyond each of these developing areas, there was a great trough or channel of deeper ocean waters, separating either from the Azoic area.

* Address &c.—See this volume, page 319.

The Azoic, as has been indicated, has something of a V shape, (or ⋁), with Hudson Bay between its arms. This succeeding step of progress is the partial development of a larger V outside of and parallel to the Azoic nucleus. The channels alluded to lie between the two V's. The bar of the outer V on the left is of great breadth and made up of several broad parallel bands or ranges of elevations; that on the right is quite narrow comparatively, yet also etched in several parallel lines.

The Mexican Gulf is all that remains of the larger of these channels. Its waters once stretched to the Arctic Sea, and were in early time but the deeper part of the continental ocean. Later, as the ages moved on, there was land to the north, and a line of freshwater lakes along its former course; and the Gulf reached no higher than the headwaters of the Missouri. Later still, and its limits became more contracted, till now the full-grown continent has but her foot in the salt water.

The Gulf of St. Lawrence marks the outlet of the other channel, and the River St. Lawrence its course. The great lakes, as well as the smaller lakes north, lie near the limits of the Azoic nucleus within these ancient troughs or depressions; and the largest lake, Lake Superior, is at the junction of the two lines.

Such was the law of growth. The molecular forces *beneath* the continent, from the progressive cooling there going on, were not idle, and must have modified the results. But the main action causing the lifting and sinking of the crust and the final gain to the land, proceeded from the directions of the oceans. The inequality in the forces from the two directions, as well as in the form and depth of each oceanic or subsiding area whence the forces mainly came, would necessarily have produced many irregularities in the results, as I have remarked in another place,* and will not now dwell upon.

The Pacific region has always been true to its own grandeur. The force from that direction not only made the Rocky Mountains to rise and a file of lofty volcanoes to light up its waters, (while the most the gentler Atlantic could accomplish was a bending up of the strata into Appalachians, and a baking of some of the beds,) but it also added tenfold the most dry land to the continent; and even after the tertiary rocks were deposited, it elevated the continental border at least two or three thousand feet—ten times beyond what happened on the Atlantic side.†

* Amer. Jour. Sci. [2], vol. iii.

† Whatever doubts may exist as to the cause, there can be none as to the actuality of the force on the two sides, the Atlantic and the Pacific. The elevation of the mountains on each border is proof beyond question; and their relative extent and height is evidence indubitable as to the relative amounts of force exerted. The parallel *folds* on the Atlantic side show that there it *was actually lateral* force from the southeast; and the several parallel ranges on the Pacific side, parallel to the

But look further, and consider that the great lines of elevation on the Pacific side are parallel nearly to the islands of the ocean; that these islands are like a long train stretching off from Asia to the east-southeast; that New Hebrides, New Caledonia in the southwest, with the foot of the New Zealand boot and northwestern Australia, conform to the general parallelism; and it will then be comprehended that we have been considering not simply a continental system of progress, but one involving the whole globe. It appears also from the history of the coral islands of the Pacific, that while the Tertiary and Post-tertiary elevations were going forward on the Pacific border of North America, a slow and gradual subsidence was in progress over a parallel region across the middle of the ocean. The axis line of the Pacific is not only the main trend of its lands, but is also nearly the course of the great subsidence which is indicated by the history of the coral islands.*

III. I have said that these two systems of forces—the southeast and southwest—continued to act through the Tertiary period, working out the continent, and bringing it nearly to its adult extent. At the meeting of this Association at Providence I pointed out the fact that at the close of the Tertiary there was a change in the movement; that during the following period, the Post-tertiary, there were high-latitude oscillations; and I endeavored to show, that there was first an elevation of the continent over the north for the first or glacial epoch; then a subsidence (as shown by the seashore deposits on Lake Champlain, and the highest terrace of the lakes and rivers) during a second or Laurentian epoch; and finally, an elevation to its present height, for the third or Terrace epoch. Whether the elevation for the Drift epoch be admitted or not, all agree that the oscillation attending it was a northern phenomenon. These several changes thus affected mainly the latitudes north of the middle of the temperate zone, or were but slightly felt to the south of this. It is a remarkable fact that the coasts of the Arctic regions, which have now been rather widely explored, have not presented any Jurassic, Cretaceous or Tertiary deposits, and there is, therefore, no evidence of their

ocean, are proofs of similar lateral action there, but from the southwest. Then the dominance of these two trends in the uplifts over the whole continent in its oldest and newest regions and rocks, are like the warp and woof of a fabric, determined by the organizing forces themselves of the structure.

* Amer. Jour. Sci. vol. xlv, (1843) 131, and [2], iii, 396, (1847).

One consequence of these facts and principles may be here alluded to.—If the position of the Atlantic and Pacific has determined the main directions of the organizing forces through all time, and if, owing to the direction, as the facts show, elevations having the *same* strike or trend have been formed in successive geological ages, it is evident that the elevation theory of mountains, sustained by Elie de Beaumont, must be received with much hesitation. One dial-plate for the world, such as he has deduced mainly from European geology, is a splendid hypothesis; but it may not mark time for America or the other continents.

having been in those eras under water. Such beds may hereafter be detected; but the great fact will still remain, that they are there of limited extent, if not wholly absent. As far as known, there is no Tertiary on the coasts north of Cape Cod. All development or growth there seems to have ceased, or nearly so, with the Palæozoic era or the close of the Carboniferous age. But there are Post-tertiary deposits in the Arctic regions in many places, situated hundreds of feet above the sea, containing shells of existing Arctic species. This alone, independent of other evidence, would prove a change in the conditions of geological progress after the Tertiary period. The necessary inference is, then, that as long as the southwest and southeast forces were in active play, and the extremities of the continent were thereby in process of growth, there was little change going on in the far north. But when the continent was nearly finished, its extremities grown, and the stability consequent upon adult age acquired, then, through a series of oscillations, a course of development was carried on in the more northern regions, giving a final completion to the continent—an action, which, as I have elsewhere explained, involved the higher latitudes about the whole sphere, north and south of the equator.*

We shall understand more definitely the relations of the later to the older oscillations, if we consider that all were due to one grand cause, influencing the whole extent of the continent even to the Arctic ocean; that the force from the north, the southeast, and the southwest, according to the principle explained, was proportioned approximately to the sizes of the oceans, the Arctic, the Atlantic and the Pacific; that the greater forces from the southeast and southwest acted against that from the north, and through their superior strength or the concurrent greater flexibility of the crust, kept up those vibrations in the progress of which the border mountains were made; but at last, the southeast and southwest action almost ceasing through the stiffening and uplifting of the crust, then the northern force, having a stable fulcrum, made itself felt in the long and slow oscillations of the Post-tertiary. Under this mode of view it will be seen that all was part of one system of development.

If we rightly apprehend the results of the Post-tertiary period, we shall perceive that there was vast importance in these finishing operations over the sphere:—that during its progressing centuries, the great phenomena of the drift took place, covering hills and plains with earth; that the valleys for our rivers were then either made or vastly enlarged; that immense alluvial plains were spread out in terraces over the interior and in flats along the shores; that thus a large part of the brighter fea-

* Address, etc., this volume, p. 327.

tures of the globe were educed. The mountains of the earth at last stood at their full altitude, having gained some thousands of feet since the Tertiary; and rivers, true offspring of the mountains, taking their size from the size of the mountain ranges, were sent on renovating missions over the breadth of the continents. Indeed, the upper terraces of the rivers show that during the Post-tertiary, these interior waters had an extent and power vastly beyond what the streams now exhibit;—an extent which is yet unexplained, unless attributable, as I have suggested, to the declining snows of a glacier epoch. In their strength, they deeply channeled the hills, and wrought out much of the existing sublimity of mountain architecture. There was the elimination of beauty and of immediate utility in every stroke of those later waters, in striking contrast with the earlier operations of rock-making and mountain-lifting; for those very conditions, those special surface details, were developed, that were most essential to the pastoral and agricultural pursuits with which man was to commence his own development, while that grandeur was impressed on the earth that should tend to raise his soul above its surface.

This transfer of the process of development from the extremities to the more northern regions, thence evolving these new and more refined qualities of inorganic nature and humanizing the earth, has a parallel in organic growth; for the extremities are finished and adult size attained before the head and inner being are fully perfected. The analogy is fanciful; yet it is too obvious a parallelism to be left unsaid on that account.*

* I have alluded on a former page to an analogy between the progress of the earth and that of a germ. In this, there is nothing fanciful; for there is a general law, as is now known, at the basis of all development, which is strikingly exhibited even in the earth's physical progress. The law, as it has been recognized, is simply this :—Unity evolving multiplicity of parts through successive individualizations proceeding from the more fundamental onward.

The earth in igneous fusion, had no more distinction of parts than a germ. Afterwards, the continents, while still beneath the waters, began to take shape. Then, as the seas deepened, the first dry land appeared, low, barren, and lifeless. Under slow intestine movements and the concurrent action of the enveloping waters, the dry land expanded, strata formed, and as these processes went on, mountains by degrees rose, each in its appointed place. Finally in the last stage of the development, the Alps and Pyrenees and other heights received their majestic dimensions and the continents were finished out to their very borders.

Again, as to the history of fresh waters.—The first waters were all salt, and the oceans one, the waters sweeping around the sphere in an almost unbroken tide. Fresh waters left their mark only in a rain-drop impression. Then the rising lands commenced to mark out the great seas, and the incipient continents were at times spread with fresh-water marshes into which rills were flowing from the slopes around. As the mountains enlarged, the rills changed to rivers, till at last the rivers also were of majestic extent, and the continents were throughout active with the busy streams, at work channeling mountains, spreading out plains, opening lines of communication, and distributing good every where.

Again, the first climates were all tropical. But when mountains and streams were attaining their growth, a diversity of climate, (essential to the full strength of

Thus, then, the continent was completed. Contraction was the power, under Divine direction, which led to the oscillations of the crust, the varied successions in the strata, and the exuviations of the earth's life, era after era. Acting from the Atlantic and Pacific directions, it caused the southern prolongation of the growing land from the icy North to the tropics, while it raised mountains on the borders, and helped to spread the interior with plains, varied slopes, and lakes. And, finally, through its action over the north, the surface received its last touches, fitting it for a new age—the Age of Mind.

the latter,) was gradually evolved, until winter had settled about the poles as well as the earth's loftier summits, leaving only a limited zone,—and that with many variations,—to perpetual summer.

The organic history of the earth, from its primal simplicity to the final diversity, is well known to exemplify in many ways the same great principle.

Thus the Earth's features and functions were successively individualized:—first, the more fundamental qualities being evolved, and finally those myriad details in which its special characteristics, its magnificent perfection, and its great purpose of existence and fitness for duty, largely consist.